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DEPARTMENT OF LANDS AND FORESTS

Conservation Authorities Branch

HON. J. WILFRID SPOONER
Minister

F. A. Mac DOUGALL
Deputy Minister

A.S.L. BARNES
Acting Chief

WHITSON VALLEY CONSERVATION REPORT

1962

WATER SECTION

ONTARIO

TORONTO
1962

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The Honourable J. Wilfrid Spooner,

Minister,

Department of Lands and Forests,

Parliament Buildings,

Toronto 2, Ontario.

Honourable Sir:

I take pleasure in transmitting herewith the Water Section of the Conservation Report for the Whitson River in the District of Sudbury.

Yours very truly,

A.S.L. Barnes
Acting Chief
Conservation Authorities Branch

Toronto, January 31, 1962.

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AUTHORSHIP

The field work and preparation of this report were done by A. F. Smith under the direction of J. W. Murray.

Editing and format were under the personal supervision of A.S.L. Barnes, R.P.F.

ACKNOWLEDGEMENTS

The preparation of this report required considerable dependence upon numerous people living and working in the Whitson Valley and vicinity, who had first hand information and experience with the problems attendant upon the Whitson River and its tributaries.

It is a pleasure to record the courtesies and assistance provided by the members of the Authority, Municipal officials, local residents, the International Nickel Company of Canada, and several Departments of the Provincial Government.

The flood photographs supplied by the Sudbury Star and the assistance of Mr. Wm. Powell, Consulting Engineer, and the firm of Lane, Lane, Lewis and Associates, are also gratefully acknowledged.

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RECOMMENDATIONS

STATED OR IMPLIED IN THIS REPORT

THAT the Authority:

1. Acquire or encourage municipalities to zone flood-plain lands as indicated on the flood plain mosaics to restrict the use of lands which are subject to flooding. The zoning should provide for recreation, wildlife or agricultural uses commensurate with the flood hazard.

2. Establish water level gauges and precipitation stations to obtain accurate information for the design and operation of water control facilities and for the efficient management of the available water supply.

3. Construct a low, concrete, overflow dam at the outlet of Whitson Lake to provide flood control and water supply storage at an estimated cost of $30,000.

4. Construct the Bailey Dam and Reservoir for the purposes of flood protection, summer flow, water supply, fire protection and recreation at an estimated cost of $240,000.

5. Construct a dike at Val Caron to provide flood protection at an estimated cost of $72,000 ($85,000 with roadway).

6. Promote good drainage practices throughout the watershed to help alleviate some of the minor flood problems in tributary regions, particularly where there is urban development.

7. Construct a low dam at the outlet of Garson Lake to retard the run-off at an estimated cost of $2,000.

8. That the Authority consider the development of one or more community ponds with recreational facilities along the river. In particular, the region from Highway 544 north

through Chelmsford to one mile upstream of the Balfour-Rayside Township line.

Note:- All the estimated costs given above are exclusive of land costs.

CHAPTER 1

INTRODUCTION

1. Scope and Nature of Report

In the autumn of 1959 the organized municipalities having land drained by the Whitson River and its tributaries voted to establish the Whitson Valley Conservation Authority. The Authority is interested in many phases of conservation work including land use, forestry, recreation, history, water and wildlife. Though all features of water conservation are of definite interest the most pressing water problem at present is that of flood control. This water conservation report will give major emphasis to the problems of flood control for the Whitson Watershed.

Since water is a resource of which man makes many uses it is unrealistic to try to treat the flood control problem in isolation. Therefore, mention will be made of related water conservation features such as water for municipal supply, fire protection, recreation and pollution abatement while dealing in detail with the flood problem. It frequently happens that in a region where water causes great damage and is wasted during a period of flood there are subsequent periods when water is not available in sufficient quantity to meet the needs of the people in the region. If a single structure can be built to store water from periods of excess flow for later use in dry times then a more wide-spread benefit is received from the structure and a greater measure of water conservation is achieved.

2. Location and General Description of Watershed

The Whitson Valley Watershed is located in the district of Sudbury, three miles north of the city of Sudbury. It is bounded by the Wanapitei Watershed on the east, the Vermillion Watershed on the north and west and by the Junction Creek Watershed on the south.

The watershed, having a drainage area of 122.6 square miles, is oblong in shape with a length of 22 miles and an average width of 5.6 miles. The central part of the basin is a lacustrine* deposit while the outer rim is largely rock. At one time the whole area was covered by a glacier and as the temperatures moderated and the icecap receded many lakes were formed. These lakes in time found outlets through soft or low spots in the bed rock or soil formation. What is now the Whitson Valley was once one of these lakes draining from east to west into the Vermillion River. As the glacial melt waters flowed into the basin soil particles carried by the glacier settled to the bottom. The larger particles, sands and gravels, settled shortly after entering the lake while the smaller particles, silts and clays, were carried to the downstream regions.

There is a general gradation from coarse sands in the eastern part of the watershed to fine sands and silty clays in the south-west. This gradation has an important bearing on the water retaining characteristics and infiltration index for the area.

The land use and forest cover of the watershed will be dealt with in these respective sections of the full Conservation Report.

The municipalities within the watershed are:- The town of Chelmsford and parts of the townships of Balfour, Blezard, Capreol, Falconbridge, Neelon-Garson, Hanmer, Rayside, Creighton and Lumsden. Chelmsford with a population of 2,477 is the only urban centre in the watershed. Total population within the watershed is 11,878. The areas, populations and percentage of each within the watershed for the various municipalities are shown in Table 1.

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* Lacustrine materials are materials deposited by lake water.

TABLE 1

MUNICIPALITIES, AREAS AND POPULATION IN THE WHITSON VALLEY CONSERVATION AUTHORITY

Municipality	*** Area				% of Municipality Within Watershed	Population	
	Total for Municipality		Within the Watershed			* Total for Municipality	Within Watershed
	Sq. Miles	Acres	Sq. Miles	Acres			
Chelmsford Town	0.9	603	0.9	603	100	2,477	2,477
Balfour Township	36.4	23,277	7.8	5,018	22	1,786	393
Blezard Township	35.8	22,906	24.2	15,494	68	3,859	2,624
Capreol Township	38.4	24,602	20.4	13,139	53	1,597	846
Falconbridge Township	23.4	15,000	1.3	838	6	1,338	80
Neelon & Garson Township	71.9	45,997	17.1	10,925	24	5,254	** 840
Hanmer Township	38.3	24,506	21.3	13,702	56	3,271	1,832
Rayside Township	34.1	21,805	20.7	13,267	61	4,568	2,786
Creighton Township	34.4	22,000	3.8	2,496	11	Unorganized Township No figures Available	
Lumsden Township	31.8	20,346	5.1	3,277	16	"	"
Totals	345.4	221,042	122.6	78,445	-	24,150	11,878

* From 1961 Municipal Directory
** Calculated by taking 24% of 2/3rds total population
*** Measured from Topographic Map with Planimeter

31, Oct. 1961

3. The River and Its Tributaries

The Whitson River is not large in comparison with some of the other rivers in Ontario and is itself a tributary of the much larger Vermillion River system. However, it is an important tributary particularly in view of the development of the area which it drains.

The headwaters of the river are located in the townships of Neelon-Garson and Capreol at an approximate elevation of 975 feet above sea level. The river flows in a general westerly direction as far as the town of Chelmsford and thence south-westerly to its outlet on the Vermillion River at elevation 833 feet. The total drop from the source to its mouth is approximately 142 feet in a distance of 40 miles for an average gradient of about 3.5 feet per mile. This gradient is just sufficient to permit the river in periods of high flow to carry away the sediment brought to the main channel by the tributaries.

Of the many tributaries only two have proper names being the Whitson and Garson Lake tributaries. The gradients of the tributaries are much steeper than those of the main channel and have a direct bearing on the rate of run-off and the flood problem in the central portion of the valley.

The main channel with its low gradient, meandering path and wide valley flats has the appearance of a mature river. Maturity in this sense refers to a stage of development rather than age and indicates that the lacustrine deposits through which it flows are easily eroded. Maturity on the other hand does not imply that erosion has ceased. The river channel is constantly shifting and adjusting itself to the variations in flow. Erosion will continue as long as the river continues to run with the rate or amount varying with the velocity of the flow. Merely doubling the velocity of flow increases the river's capacity to transport material of a given size thirty-two times and the size of particles that it can roll along the

bed by as much as sixty-four times. Thus it is readily clear why such damage occurs during periods of high flow when the stream velocities are increased probably as much as three and four times or more. Also in the planning of river control works or any structures adjacent to or over streams it is necessary to take full cognizance of the forces to be dealt with if the results are to be effective and permanent.

In addition it must be recognized that the plains or valley flats properly belong to the river. This floodway may not be used for several years but periodically due to excessive precipitation and other factors this supplementary channel, which the river has made for itself, will be flooded.

CHAPTER 2

WATER PROBLEMS

1. Flooding

It is evident that floods on the rivers of Ontario did not begin with the coming of the white man. Floods are generally spoken of as annual events in the first known references to them by early settlers. However, specific mention of floods at identifiable times and places did not begin until the business of travel, settlement, road building and other civilizing activities had given the newcomers an interest in areas subject to flooding.

In recent times the Whitson River has flooded significantly in 1927, 1935, 1950 and 1960. Sketchy records indicate that the river spilled over its banks in other years since 1927, but with little resultant property damage. People generally have taken little notice of flooding until they have suffered damage or distress. By definition a flood may be the occurrence of any flow that overtops the natural or artificial banks of any reach of a river channel. Such flows can and often do occur without causing any significant damage.

Hydrometeorological events can give rise to many degrees of flood severity. The height and speed of the water which spreads out over the flood plain as well as the density of human usage and property build-up in the flood plain largely determine the extent of damage from any particular flood.

Fortunately to date the areas of significant flood damage are quite localized in the Whitson Watershed. These areas are near the built-up, urbanized centres. Along the main stem of the Whitson River the major urbanized centres are the town of Chelmsford and the region near Val Caron. In addition subdivisions are rapidly being developed near the river and its major tributaries in Hanmer, Garson, Blezard and Rayside Townships. The fact that flood damage has not been

great in the region along the river between Val Caron and Chelmsford or downstream of Chelmsford in past years, does not mean that these lands are not subject to flooding. It is merely an indication that the lands near the river in these regions have not been developed for uses which are subject to appreciable flood damage. The lack of significant monetary losses due to flooding in these regions should not be looked upon as sufficient justification for building houses or industries near the river in these zones. They are definitely subject to overflow and are hazardous to urban development.

It is folly to proceed with the urban development of an area and wait until the river has inflicted damage or disaster before examining the flood potential. Once the potentialities of the river and its valley are known development can proceed in harmony, rather than in conflict, with the river. In order to assess the flood potential of the river and arrive at sound methods for protecting the existing areas in the valley which are subject to flooding certain pertinent physical and climatic factors must be investigated.

2. <u>Low Water</u>

The flood problem is merely the forerunner of water problems to come. The less obvious problems are municipal water supplies, a minimum sustained flow for sewage dilution and recreation. As the valley becomes more heavily populated these problems will become more acute and particularly the problem of pollution. At present, Chelmsford depends upon the river for drinking water and sewage dilution. Blezard Township wishes to use Whitson Lake as a source of water supply.

Thus the second phase of the water problem is to ensure an adequate summer flow. This is often considered to be secondary to flood control but with the growing demand for adequate water supplies and water facilities for recreation it is an important consideration. In many cases it justifies the

The result of building on the Flood Plain. The 1960 flood at Val Caron looking east from Highway 69

A desirable site?

Severe property damage was one inconvenience of the 1960 flood at Val Caron.

CHAPTER 3

HYDROLOGY

Hydrology encompasses the behaviour of water as it occurs in the atmosphere, on and below the ground surface. The movement of water from the atmosphere to the earth and back to the atmosphere is known as the "hydrologic cycle". There are many factors which influence this water movement and particularly that portion of the cycle between the incidence of precipitation over land areas and the subsequent discharge through stream channels or direct return to the atmosphere by evaporation and transpiration.

The drainage area of the Whitson River is subject to the constant phases of the hydrologic cycle, and not unlike other areas, problems exist which are peculiar to the climatic and physical characteristics of the area.

1. Climatic Characteristics

The climatic factors affecting run-off are extremely variable but with sufficient and accurate observed data recorded over a long period of years these factors can be evaluated for an area with a reasonable degree of confidence. Observed data recorded daily will keep one informed as to existing ground and run-off conditions and with weather forecasts the people in the area may be alerted when a potential danger exists. Unfortunately there are no observation stations on the Whitson Watershed.

The more important climatic factors which influence the rate and volume of run-off are the amount and intensity of rainfall, amount of snow and ice accumulation, temperature, and direction and velocity of the wind. The only meteorological observations available for any length of time are those taken at Sudbury since 1947. These records indicate that the mean annual total precipitation for the area is 28.5 inches of which 20.6 inches comes as rain and 7.9 inches in the

form of snow. (One inch of water is taken as the approximate equivalent of 10 inches of newly fallen snow.)

Thus for an average winter 79 inches of snow falls in the area and with an average winter temperature of 18 degrees fahrenheit most of it will remain. The maximum recorded annual snowfall amount was 121 inches for the winter of 1950-51 and the minimum was 47 inches for the winter of 1947-48. The snowfall recorded for the winter period preceding the 1960 spring flood was 100 inches.

The Whitson River floods occur mainly in the spring due to the combination of snowmelt and rainfall. If the temperature rise in the spring is gradual, with thawing during the day followed by freezing temperatures at night, the snow and ice melts intermittently and slowly, allowing the water to get away with little or no flooding. On the other hand, a sudden rise in temperature with night temperatures also above freezing results in rapid melting of snow and ice, and consequent heavy run-off over the usually frozen ground surface to the tributary and main stream channels. Should the channels contain a thick ice sheet, which melts slower than snow, rising flood waters normally break it up into large floes which may jam at constrictions in the channels and aggravate flood conditions.

Even though the majority of floods in the Whitson River area are due to spring freshets, flooding can also be expected to occur through other seasons of the year due to intense rainfall only. There is no doubt that a serious flood situation would result on this watershed should a storm of the magnitude of hurricane "Hazel" occur as it did over the watersheds in Southern Ontario and particularly in the Metropolitan Toronto region where rainfalls in excess of 8.4 inches in 24 hours were recorded. The 24-hour rainfall amount for hurricane "Hazel" over the Sudbury area was 2.87 inches.

This is not the greatest. An amount of 5.2 inches for 24 hours was recorded in the area by the International Nickel Company in September 1937. Other 24-hour amounts ranging from 2.37 to 3.55 inches have been recorded during the past 20 years. Furthermore rainfall amounts in excess of these figures were recorded for these same storms in areas adjacent to the Whitson Watershed which could have just as easily occurred over this watershed.

As mentioned previously there are no meteorological observations being taken on this watershed but there is a first class weather station at the Sudbury airport. This is close enough to be of use but as yet the period of records is hardly sufficient for reliable analysis of the existing climatic conditions or an accurate determination of the precipitation to run-off ratio for the area. Furthermore, these records and particularly the rainfall observations should be supplemented with observations made at strategic points within the watershed and, if possible, at least one recording rain gauge should be installed in the area.

Several temporary rain gauges were installed during the time of the field surveys and useful records were obtained from one of these. However, these had to be abandoned because of lack of interest on the part of the observers.

2. Physical Characteristics

The physical characteristics of an area, which are of concern here, are those natural features of the terrain which either accelerate or retard run-off, and are related directly to that area defined as the drainage basin.

A river drainage basin or watershed is the area drained by a river and its tributaries and the boundary of this area is determined by the physiographic features of the terrain alone. These boundaries and a tabulation of pertinent drainage

areas for the Whitson Watershed are shown on the accompanying watershed map at the back of the report.

The physical factors affecting run-off are numerous and varied and appear in so many combinations that it is difficult to classify their direct effect. However, most of them are more or less constant or change slowly enough that their influence may be noted. Run-off is the resultant of all the watershed characteristics and though it reflects the combined influence of the various factors on the precipitation that falls on the area, it does not indicate the significance of any one factor.

Some of the more significant physical characteristics that affect the rates and distribution of run-off and thus the streamflow are:

(a) Size and shape of drainage area,

(b) Channel shape, gradient and capacity,

(c) Land slopes,

(d) Stream pattern and density,

(e) Artificial or natural storage in lakes, ponds and swamps,

(f) Geology and surface slopes,

(g) Soils and land use pattern,

(h) Vegetal cover.

In the easterly half of the headwater region of the Whitson Watershed there are seven natural lakes of which the Whitson, Garson and Moose Lakes are the largest and most important. These lakes act as natural retardation basins and tend to reduce flood peaks downstream. The Whitson and Garson Lakes in particular could be used more effectively in reducing downstream flood peaks in addition to providing storage of flood waters for later use. This possibility is dealt with in detail in the section concerning reservoirs. The swamps on the watershed act in a similar manner tending to reduce flood peaks downstream

and improve the summer flows. Storage in the swampy areas retained from the abnormally high spring run-off is largely responsible for the good flow in the river throughout the following summer months.

The geological development of the Whitson basin gives some clue to the major soil formations, which are significant in terms of run-off and flood flow characteristics. As mentioned in the description of the watershed this area is a shallow basin with graded lacustrine deposits in the central portion and more or less bare rock around the rim.

The permeable deposits in the upper part of the watershed absorb water more readily than clays, hence, the direct run-off from intense rainfalls or rapid snowmelt in this area would be much less than from the relatively impervious clay soils at the lower end of the basin. Precipitation which percolates through the soil becomes ground water and eventually reaches the stream channel, while still another portion known as interflow follows a devious path to the stream channel without reaching the water table.

Flooding occurred on the Whitson River during the spring break-up period of 1960, due to snowmelt accompanied by rainfall, and it is estimated that approximately fifty percent of the total precipitation was absorbed into the soil. Much of this water was emitted later in the spring and early summer and helped maintain a good flow in the river throughout the summer. This spring flood might have been more serious had there been less snow cover on the ground in the fall and early winter, which would have allowed the ground to freeze to a greater depth. Also had the spring thaw been completed in a shorter period of time, the majority of snowmelt water would have run off directly with very little infiltration into the ground.

Another important physical factor is the slope of the stream channels or gradients which have a direct

influence on the discharge capacity of the channel. If two streams have similar physical characteristics but different gradients the streamwith the steeper gradient will have the greater discharge capacity.

The Whitson River has a gradient of about 4 to 5 feet per mile throughout most of its length, as can be seen from the accompanying water level profile (Figure 1). This is a flat gradient in comparison to many of the rivers in Southern Ontario which have average gradients of 20 feet or more per mile. The mild slope of the Whitson reduces its capacity to convey the high inflows into the central part of the valley away quickly with consequent flooding for prolonged periods.

The slope of the terrain over which run-off must pass to reach the streamchannels is also an important physical characteristic and usually referred to as the "lateral slope". Although vegetation partially impedes surface flow and increases the opportunity for infiltration, the slope of the land is significant in determining the rate at which run-off reaches the tributary water courses.

There is a distinct difference between the watershed slopes on the north side of the Whitson River and those on the south side. About 50 per cent of the watershed, including the north side, is comparatively flat with few well defined channels to convey run-off to the tributaries. In the southern portion of the watershed, and particularly the area south and east of Val Caron which includes land draining into the Whitson and Garson Lakes, the lateral slopes are as steep as 1,300 feet per mile.

From the above physical features the run-off pattern becomes more identifiable. With the occurrence of adverse climatic conditions the run-off from rainfall and/or snowmelt moves rapidly from the steep border areas and concentrates in the central part of the valley due to the low

FIG. I

WATER LEVEL PROFILE

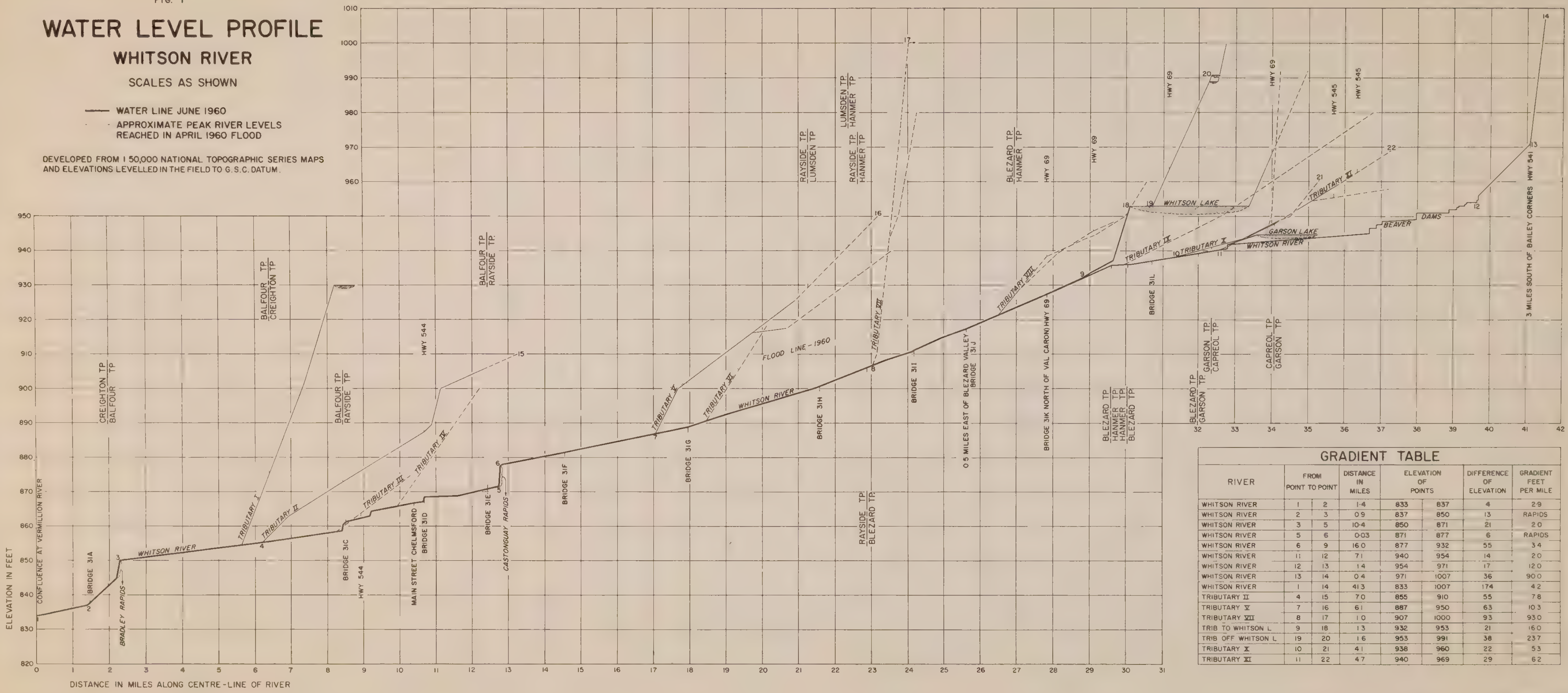
WHITSON RIVER

SCALES AS SHOWN

WATER LINE JUNE 1960

APPROXIMATE PEAK RIVER LEVELS REACHED IN APRIL 1960 FLOOD

DEVELOPED FROM 1 50,000 NATIONAL TOPOGRAPHIC SERIES MAPS AND ELEVATIONS LEVELLED IN THE FIELD TO G.S.C. DATUM.



GRADIENT TABLE

RIVER	FROM POINT	TO POINT	DISTANCE IN MILES	ELEVATION OF POINTS		DIFFERENCE OF ELEVATION	GRADIENT FEET PER MILE
WHITSON RIVER	1	2	1·4	833	837	4	2·9
WHITSON RIVER	2	3	0 9	837	850	13	RAPIDS
WHITSON RIVER	3	5	10·4	850	871	21	2 0
WHITSON RIVER	5	6	0·03	871	877	6	RAPIDS
WHITSON RIVER	6	9	16 0	877	932	55	3 4
WHITSON RIVER	11	12	7 1	940	954	14	2 0
WHITSON RIVER	12	13	1 4	954	971	17	12 0
WHITSON RIVER	13	14	0 4	971	1007	36	90 0
WHITSON RIVER	1	14	41 3	833	1007	174	4 2
TRIBUTARY II	4	15	7 0	855	910	55	7 8
TRIBUTARY V	7	16	6 1	887	950	63	10 3
TRIBUTARY VII	8	17	1 0	907	1000	93	93 0
TRIB TO WHITSON L	9	18	1 3	932	953	21	16 0
TRIB OFF WHITSON L	19	20	1 6	953	991	38	23 7
TRIBUTARY X	10	21	4 1	938	960	22	5 3
TRIBUTARY XI	11	22	4 7	940	969	29	6 2

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gradient of the main channel which retards the flow to the Vermillion River.

3. Streamflow

Streamflow and run-off consist of surface flow and ground water which enter the stream along its course and are broadly the excess of precipitation over evapo-transpiration and deep seepage. Surface flow is that portion of rainfall, melted snow or ice, or both, which reaches the stream channels directly by flowing over the ground surface. Ground water flow (percolation) is going on continuously and is mainly responsible for maintaining flow in streams during periods of drought. This is sometimes referred to as base flow.

Measuring and timing of the surface flow, or direct run-off, are of great concern, since accurate data concerning them make possible a more reliable solution of the particular problems relative to water conservation in general and flood control in particular.

Regular observations of streamflow have been recorded on the Whitson River at Chelmsford from July 1961 to the present and river stages have been recorded at Val Caron since October 1960. As in the case of the climatic data streamflow records are obviously not of sufficient length to permit a reliable analysis of the run-off. The gauges installed are the manual type and are observed twice daily only, with possible occasional extra readings during flood periods. The Chelmsford gauge will be replaced with a recording type when the bridge at the gauge site is replaced. The maximum and minimum mean daily discharges recorded at these gauges for the period of record are as follows:

Gauge	Discharge - c.f.s.	
	Maximum	Minimum
Chelmsford	397 - April 17/61	13 - February 11/61
Val Caron	185 - April 17/61	8 - February 8/61

Fortunately, a few flood peak levels were noted by interested local citizens from which, with field measurements taken during the survey in 1960, a series of peak discharges at the town of Chelmsford were developed. These are tabulated below:

TABLE 2

COMPUTED PEAK DISCHARGES - CHELMSFORD

Year	Discharge in c.f.s.
1927	1,700
1935	1,490
1950	1,580
1960	1,283

From a frequency analysis of the above the 1960 flood appears to be of the order of a 10-year flood, which implies that there is a 10 per cent probability that it will be equalled or exceeded in any one year. This 10-year flood could be classified as the "regional flood", or that which is considered to be the common type of flood causing significant damage in the watershed. In addition to the flood peaks determined at Chelmsford, a hydrograph for the 1960 flood at Val Caron was developed from the few observations made there during the flood by interested residents.

4. <u>Design Flows</u>

The "design flood" flow is generally referred to as the peak discharge that is adopted as the basis for the design of any river control structures. This discharge is dependant on consideration of the flood flow characteristics of the particular area as well as economic and social factors. There are three measures of evaluation which are generally considered standard practice in the design of remedial measures for most flow problems. These are:

(a) The Regional Flood is that which implies the most common type of flood causing significant damage in the watershed.

(b) The Standard Project Flood is usually a flow which can reasonably be expected to recur about once in 100 years.

(c) The Probable Maximum Flood is that flow which would result from the probable maximum precipitation occurring over the watershed at a time of maximum run-off conditions.

Except in cases where the maximum degree of protection is mandatory, where the loss of life or excessive damage to valuable property is concerned, it is usual to accept a limited degree of risk in the design of structures. In such cases the Regional or Standard Project Flood flow might be used. Where structures such as dams are concerned, it is not the ordinary or average flows but the exceptional flows that may occur in the future that are significant. Under these circumstances the structures must be designed to withstand the probable maximum flows which the drainage area, above the point in question, is considered capable of producing.

Having assessed the physical characteristics of the watershed and of the meteorological events likely to occur in the area, the next step is to determine more detailed values of the rate and volume of discharge in order to determine the size and type of control works needed. In addition to flood flows, low flow values are required for summer flow storage calculations and are of particular value for the design of municipal water supply and sewage systems where a minimum acceptable flow is demanded. Where long-term records are available the problem of determining design flows presents little or no difficulty. By using recognized statistical methods design flows in the order of 1 in 50 years, or 1 in 100 years may be

determined with a fair degree of accuracy. Consequently, hydrographs can be developed which will show the peak, volume and duration of run-off, enabling the engineer to select the best method of control and the size and type of structures needed.

Unfortunately, many of the flood problems occur on watersheds where records of streamflow and rainfall are inadequate, which necessitates the use of empirical and synthetic methods to determine peak flows and run-off volumes for design purposes. This often results in the uneconomical design of structures and, over the years, the waste of more money than would have been required to maintain a good gauging program. Design flow rates obtained by synthetic methods require that a factor of safety be higher than for the case where good long-term records are available.

In arriving at a solution to flood problems it is good practice not only to plan works for floods that are known to have occurred in the past but also for those which may reasonably be expected to occur in the future. For this purpose the "Standard Project Flood" or the 100-year flood is generally used. Remedial measures recommended in this report are designed to provide relief from flooding for all flows up to this magnitude.

To determine the value of flows of this magnitude it was necessary to extrapolate the existing flow data and in view of the limited data available two approaches were used as a check.

(a) Method I

From a review of the relationship of lower return frequencies to the 50 and 100-year return frequencies of the number of rivers in Canada and the United States having long periods of records, the following table was developed. The table shows a general relationship with an indication of the range of variability of the relationship.

TABLE 3

FLOOD FREQUENCY RELATIONSHIPS

Recurrence Frequency in Years	Percentage of 50-year Flood	Percentage of 100-year Flood
5	55 $\pm$ 15	45 $\pm$ 10
10	70 $\pm$ 15	60 $\pm$ 10
20	80 $\pm$ 10	65 $\pm$ 10
50		85 $\pm$ 5

Since the 1960 peak of 860 c.f.s. at Val Caron appears to be in the order of a 10-year flood, a 100-year flood as calculated from the above table should be expected to lie within the limits of:

$$\frac{860}{.7} = 1,230 \text{ c.f.s. and } \frac{860}{.5} = 1,720 \text{ c.f.s.}$$

(b) Method 2

The flood peaks at Chelmsford were assembled in the flood frequency graph shown in Figure 2. The line on the flood frequency graph was extrapolated to obtain the value of the 100-year flood peak discharge of 2,300 c.f.s. To ensure that the frequency curve for the Whitson Creek was typical of the drainage area, it was compared with the North Magnetawan River at Burks Falls which had 42 years of flow records. The watershed above the gauging point on the North Magnetawan River was similar in size and had a stream gradient similar to the Whitson. Steeper lateral slopes might account for the slightly higher discharge values on the North Magnetawan frequency curve, but the curve for the North Magnetawan has the same slope as the Whitson River frequency curve indicating that the frequency curve for the Whitson is a reasonable deduction from the scanty data available. It is realized that the Whitson River flood records represent a very short sample and could depart considerably from the long-term flood frequency relationship and extrapolation from this scanty data could introduce

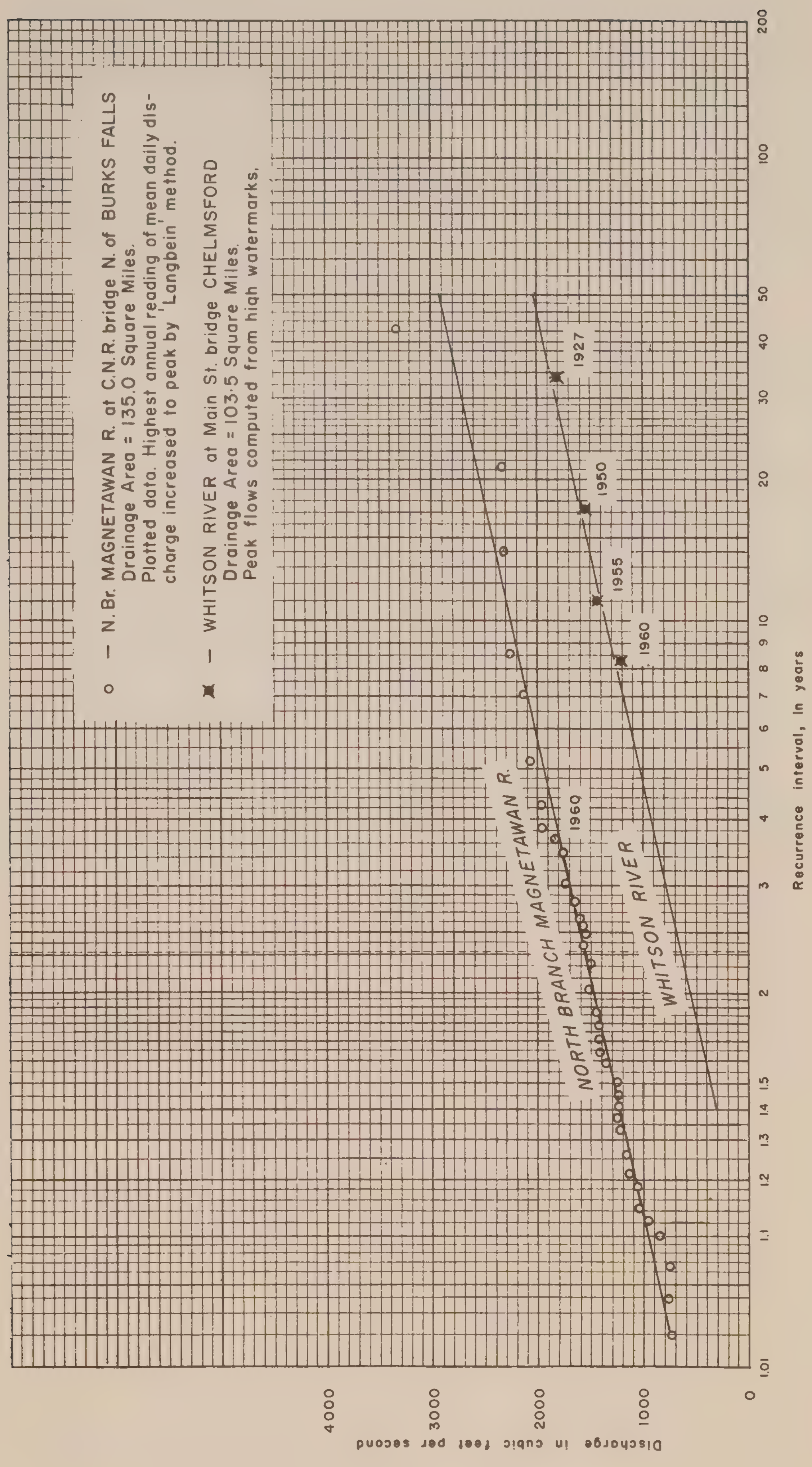
considerable error. A 100-year flood peak discharge value for Val Caron (Standard Project Flood) was obtained from the 100-year value at Chelmsford by assuming that the peak flow rate varies directly with the square root of the drainage area. This assumption should be reasonably close since the drainage areas above Chelmsford and Val Caron are of the same order of magnitude and have similar physiographic characteristics. Existing flood records both for the Whitson and many other rivers in Ontario indicate a relationship close to the square root. The 100-year peak at Val Caron thus obtained equalled 1,760 c.f.s.

This value of 1,760 c.f.s. lies near the upper limit obtained by Method I. In order to keep the calculations on the safe side a design peak discharge of 1,800 c.f.s. was used for the river at Highway 69.which is double the peak of the 1960 flood at Val Caron. The approximate 1960 hydrograph of the flood run-off for the section at the Highway 69 bridge in Val Caron is shown in Figure 3. The occurrence of a series of short rainfalls during the period of the run-off lengthened the run-off time and caused the hydrograph to show more than one peak during the flood period. In order that additional basic data will be available to aid in the final design of flood control structures for the Whitson River it is recommended that the Authority actively support a program of rainfall and stream gauging.

FIG. 2.

FLOOD FREQUENCY CURVES

MAGNETAWAN R —WHITSON R.



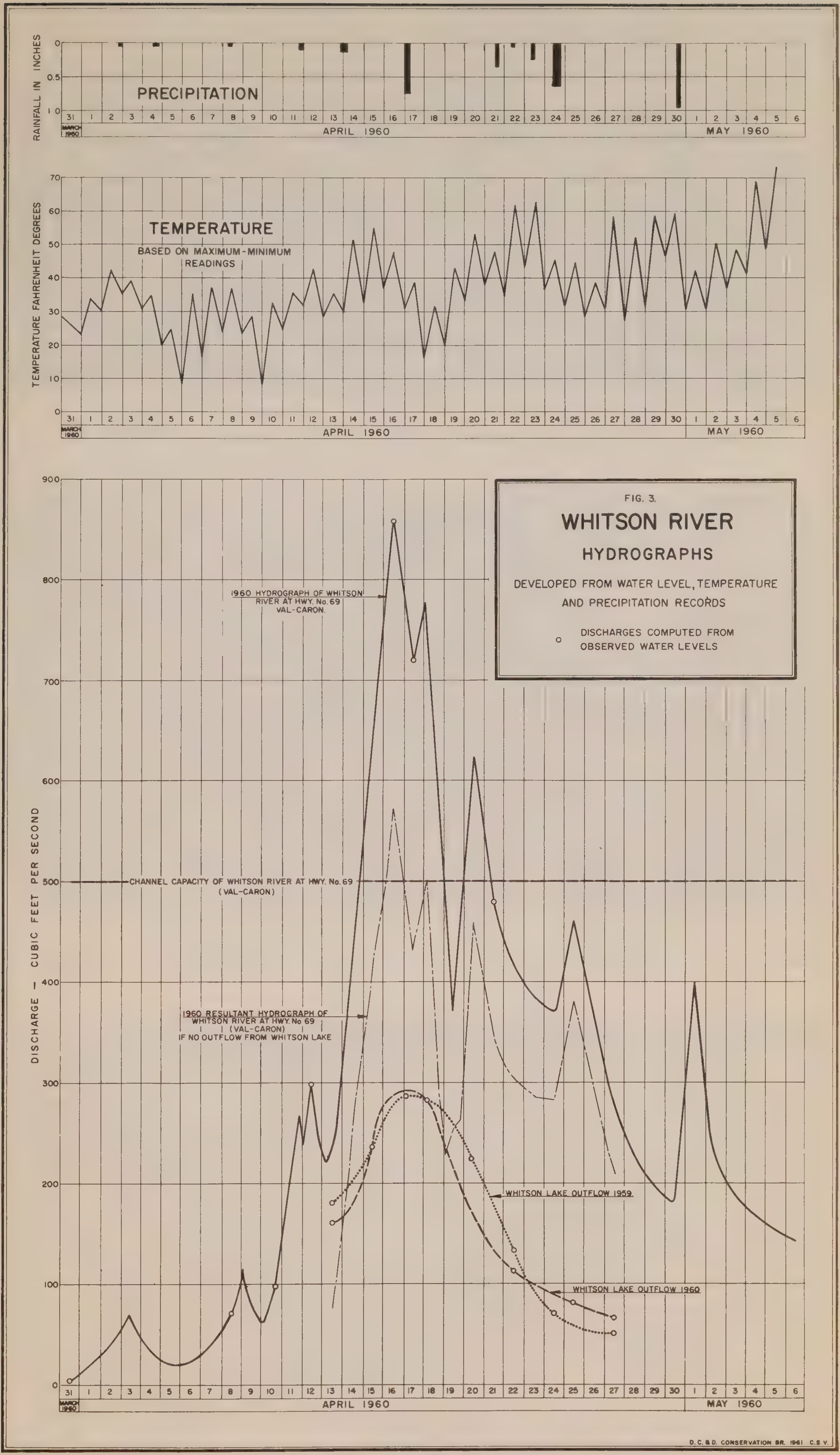


FIG. 3.

WHITSON RIVER

HYDROGRAPHS

DEVELOPED FROM WATER LEVEL, TEMPERATURE AND PRECIPITATION RECORDS

A technician from the Department of Northern Affairs and National Resources meters the Whitson River as a part of the stream gauging program. Long term continuous records of river flows are needed to provide information for the design of water control works.

Rain gauge reader supplying data for streamflow estimates. Continuous accurate records of rainfall are essential for the design of conservation projects. Interested valley citizens can greatly assist in providing conservation project design information by keeping continuous accurate records of rainfall.

Whitson Lake Dam, August 1960.

CHAPTER 4

PHYSICAL CONTROLS

1. General

In general terms, flood control methods may be divided into two types, physical controls and human controls. Where human occupancy of land subject to occasional or frequent flooding is already sufficiently dense to make relocating expensive or impractical, flood control through the construction of reservoirs and channel improvements that control the flood waters and protect the vulnerable areas must be resorted to. In some cases, however, it may not be possible or practical to control floods by physical structures and it may prove more prudent to adjust the use of the land to those in keeping with the flood hazard.

Over the years several methods have been developed to ward off floods and enable people to continue the use of lands vulnerable to flooding for a price. Each method has its advantages and limitations, and with each there are after effects. The principal methods of physical control are:

(a) Construction of dams and reservoirs to withhold temporarily, water in excess of the bank-full discharge capacity of the downstream channel. This stored water can then be released later in such quantity and at such times that it may be carried safely within the normal river channels.

(b) Expedients such as the construction of dikes, flood walls, or embankments to hold the water back from the land and confine it within definite flow channels, or channel improvements such as straightening, widening and/or deepening, to obtain an increase in the slope or cross section of the channels.

(a) Dams and Reservoirs

In considering storage reservoirs for physical control of flood waters, two limitations must be borne in mind. First, the physical conditions of the watershed must be such

that reservoirs can be constructed of sufficient size to store or retard the excess flood waters. Reservoirs should be relatively close to the area to be protected since their effect diminishes rapidly with distance upstream from the trouble area. Secondly, the cost of such reservoirs must be reasonable and less than the benefits which will result from their construction.

In the Whitson Watershed, there are three reasonably good reservoir sites namely; Whitson Lake, Bailey and Garson Lake sites. The Whitson Lake Reservoir and the Bailey Reservoir have the larger drainage areas and storage volumes and their contribution to flood relief will be the greatest. Garson Lake has a smaller storage volume and drainage area and will retard the flood waters to a lesser degree.

Even though large volumes of storage are available in the Whitson Lake, Garson Lake and Bailey Reservoirs, they would still not be sufficient to prevent flooding in Val Caron and areas downstream of Val Caron from a 100-year flood. This situation is due, in part, to the fact that less than half of the drainage area above Val Caron would be controlled by the reservoirs and in part to the very limited channel capacity through Blezard Township and downstream. The flood problem here is further aggravated by channel improvements made upstream which in effect produce a more rapid run-off. The reservoirs do have enough capacity to prevent damage from a 10-year flood or a flood similar to the 1960 flood and in addition would store water from periods of excess run-off for use during drier periods. Further hydrometeorological data is needed to accurately assess the 100-year flood and the effect of the reservoirs on the 100-year flood. It must be borne in mind that the 100-year flood occurs on the average once in 100 years but does not occur at regular intervals and may occur in any year.

(1) Whitson Lake Reservoir

This is a natural lake with a small overflow type masonry dam at the outlet to effect some regulation. With a

surface area of 1.7 square miles it is the largest lake in the watershed and receives the drainage from 13.7 square miles. Water from the lake is currently being used by the International Nickel Company of Canada for industrial purposes but some arrangement mutually satisfactory to the Company and the Authority should be made for the multiple purpose use of this lake.

It is estimated that a new dam at the outlet 3.5 feet higher than the present dam would provide 3,300 acre feet of storage which would be more than sufficient to contain the run-off from this area for a flood of the magnitude of the 1960 spring flood. Further, by drawing the lake down one foot below the crest of the present dam to elevation 952.3 feet an additional 1,000 feet of flood storage space could be made available.

The degree of protection could be further increased by lowering the lake to elevation 949.3 feet where the available flood storage capacity with the higher dam would be more than 7,000 acre feet. It is estimated that the total run-off from this area for a flood of the magnitude of once in 100 years would be about 6,000 acre feet and therefore with this control the entire flow could be held in the event of floods up to this magnitude. This additional lowering of the lake could be done in those years when the depth of snow on the drainage area reached critical proportions. The water content of the snow could be determined from snow courses set up in conjunction with a rain gauge network to provide essential precipitation data. Hydrographs for the river at Val Caron and at the outlet of Whitson Lake are shown in Figure 3.

To ensure the International Nickel Company an adequate water supply during the winter, the pump intake would be extended a distance of about 45 feet to elevation 943.0 feet. The water in Whitson Lake is of good quality and the lake might

well be used for municipal water supply for Blezard Township as well as for the International Nickel Company. There is sufficient storage volume available to satisfy both these needs as well as providing good volume for flood control purposes. Since the most frequent flooding occurs in the spring due to snowmelt, drawdown of the lake through the fall and winter could be adjusted to meet the water supply requirements and at the same time leave room for the run-off from snowmelt. The relationship betweeen the reservoir levels and the storage volumes is shown in Figure 4.

The International Nickel Company is now withdrawing 1,000 gallons of water per minute from Whitson Lake across the watershed boundary. A series of flow records for other watersheds in Ontario with similarities in physiography and drainage area embracing a 40-year period were studied along with the few records available from the Whitson Watershed. The expected minimum mean annual flow was determined to be 5 inches of run-off from the drainage area. Thus the minimum annual volume of inflow expected for Whitson Lake would be approximately 3,700 acre feet or about 1,000,000,000 Imperial gallons. The annual volume at the present rate of consumption required by the International Nickel Company is 1,940 acre feet. It is estimated that Blezard Township will require 580 acre feet for present consumption, this leaves 1,180 acre feet per year for future expansion.

To meet the basic needs of flood control and water supply it is recommended that a new dam be built at the outlet of the lake 3.5 feet higher than the existing dam. This would require that the roadway into the pumphouse be raised and that the intake be extended. The estimated cost of this scheme exclusive of land costs and the moving of 14 cottages is $30,000.

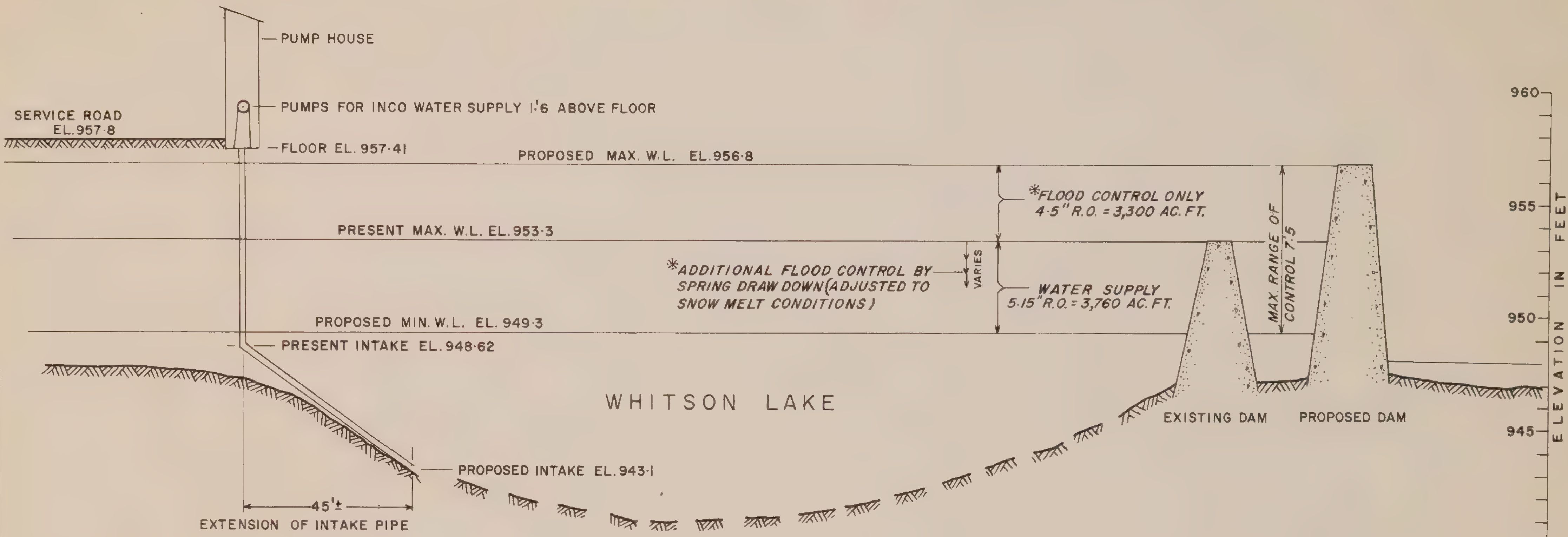


FIG. 4
SCHEMATIC VIEW
WHITSON LAKE PROPOSAL
NOT TO SCALE

* NOTE – R.O. REFERS TO RUN-OFF ON 13·7 SQ. MI. DRAINAGE AREA
MAX. CONTROLLABLE R.O. = 9·65" OR 7,060 AC. FT.
AREA OF WHITSON LAKE 940 ACRES = 1·5 SQ. MI.

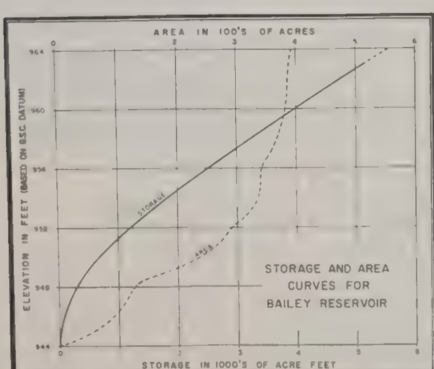
D.C.& D. — CONSERVATION BRANCH — Wm. M. 1961.

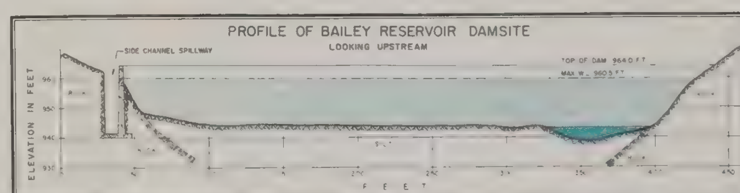
(2) Bailey Reservoir

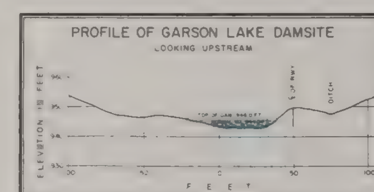
A good reservoir could be developed on the main branch of the Whitson River in Garson Township. The Bailey site located at the headwaters and controlling a drainage area of 11.7 square miles, is ideally suited for the creation of a flood control and low flow augmentation reservoir. A storage capacity of 4,500 acre feet could be created by a dam approximately 33 feet high by 410 feet long designed for a maximum water storage level of 960.5 feet elevation (G.S.C. datum). This volume is equivalent to 7.3" of run-off from the drainage area which is much higher than can be obtained in most of the reservoirs in Southern Ontario. For example, the capacity of the Fanshawe Reservoir is less than 2 inches of run-off.

The land which will be required for the Bailey Reservoir should be obtainable at a moderate cost since the reservoir would be established on flat swampy idle bottom lands bordering the Whitson River, between Baileys Corners and the C.N.R. main line to Capreol. An indication of the type of land required can be seen from the accompanying illustrations. Bordering these flat swampy bottom lands are abrupt outcrops of rock which have little or no soil cover. Near the damsite the sides and tops of these banks support a fair growth of trees, but at the upstream end of the reservoir the rock walls have been denuded of vegetation by fire and fumes. Fortunately, the rock walls bordering the valley along the Whitson River narrow to a bottom width of 350 feet which provides a suitable site for a small earth and rock fill dam. The proposed dam and reservoir area, together with the storage and area curves are shown on the accompanying reservoir plan.

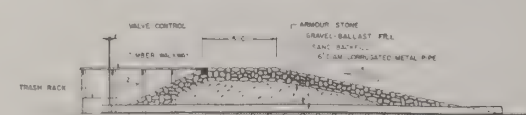
To decide whether a dam should be built of earth, concrete, or rock fill the foundation conditions and construction materials available must be analysed. An earth dam appears



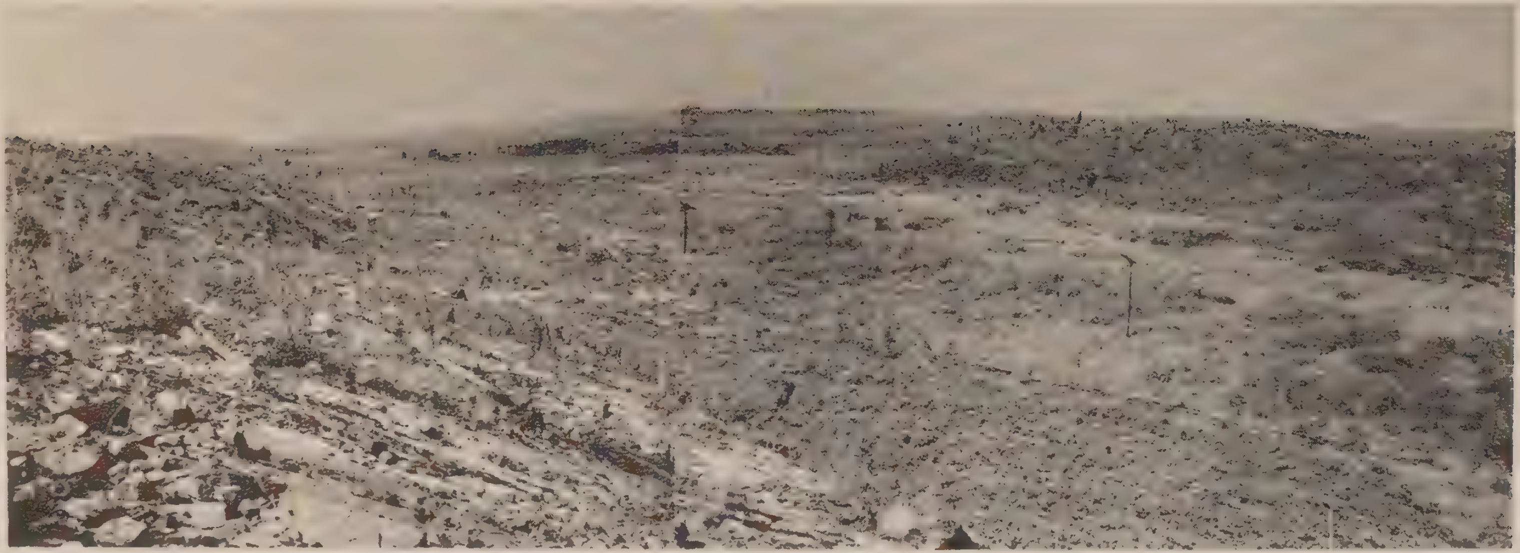




TENTATIVE CROSS-SECTION OF
BAILEY RESERVOIR DAM



TENTATIVE CROSS-SECTION OF
GARSON DETENTION DAM



Eastern edge of the Bailey Reservoir, vegetation loss due to combination of fire and continuous fume damage. In addition to flood protection, the reservoir could serve as a source of water for fire protection.

Western half of the Bailey Reservoir site has a flat, weedy, soggy floor, bounded by steep rocky slopes.

best for this site because of the silty clay foundation and the depth to bed rock. Suitable core fill should be obtainable near the site and a relatively good location for a side channel spillway exists on the northerly rock wall. Rip rap for protection of the dam slopes could be obtained from the spillway excavation. The dam cross-section, as shown on the accompanying plan, is merely an illustration of a type of earth fill dam which might fit the conditions and final dimensions will depend on detailed foundation investigations and analyses. The estimated cost of this dam and reservoir excluding land is $240,000.

(3) Garson Lake

In addition to the significant volume of storage available in Whitson Lake and Bailey Reservoirs further relief from flooding could be obtained by constructing a low loose rock-filled dam at the outlet of Garson Lake. This dam would be 3 feet high by 60 feet in length and during periods of excess run-off would raise the lake level 3 feet or more. An outlet pipe could be placed through the rock fill such that the run-off from ordinary rainfalls would pass freely, but during periods of very rapid run-off excess water would be retained in Garson Lake and allowed to drain out slowly after the run-off period had ended. The construction of this small dam, excluding land purchases, would cost approximately $2,000.

(b) Expedients

Channel improvements, dikes and diversions are classified as expedients and are not recommended when other conservation methods are possible and practical. Their only object is to get rid of the water as quickly as possible by providing adequate channel through or around the trouble area. The benefits of such measures are mainly local as they tend to increase the velocity of the flood waters and often aggravate the flood conditions at other trouble areas downstream. For reasons of economy, however, these expedients are sometimes

necessary. On rivers which have many meanders and pass through valleys of soft erodable soil great care must be taken in the design of channel improvements, dikes, diversions and cut-offs in order to prevent adverse effects due to sediment transport. These effects are described in greater detail under the specific types of expedients below:

(1) <u>Channel Improvements</u>

Channel improvements includes widening, straightening, deepening and regrading the river channel through and often for some distance below the trouble area. It is sometimes necessary to protect the banks from erosion by rip rap or other means to stabilize the new channel.

(2) <u>Diking</u>

Physical control of flood waters by the construction of dikes and flood walls are considered by many to be the obvious and complete answer to a flood control problem but haphazard diking may soon lead to greater problems than the original flood. In the words of Blench* "When people who insist in living in the flood plains of rivers have started determined action to protect themselves by dikes, the normal sequence of events, throughout the world, seems to have been dikes, higher floods, more and higher dikes, higher floods and so on without any obvious limit." Blench refers in part to the effect of silt deposition and to cases where the dikes are located on the edge of the river channel. When dikes are located right on the edge of the channel, flood waters are confined to a greater degree than in the natural river channel. Thus the river rises to a greater height in the artificially confined channel, than would have occurred if allowed to spread over the flood plain, and produces higher water velocities. The ability of a river to scour and transport sediment increases rapidly with an increase in velocity. Thus, it can be seen

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* Blench T., "Regime Behaviour of Canals and Rivers" Butterworth Scientific Publications, p.p. 110.

that where dikes are built close to the main channel on each side of the river there will be an increase in the amount of sediment picked up in the diked section. Much of this sediment will be deposited along the river bed at the downstream end of the diked section where the river waters slow down and spread out over the valley. This raises the stream bed reducing the gradient and makes the situation worse in the area which was to be protected by the dikes. This sedimentation process is illustrated overleaf. The rise of the channel bed and flood levels and the undesirable change in sediment transport capacity can be partially avoided by placing dikes well back from the channel edge beyond the meander width of the river. The location of dikes a reasonable distance from the channel bank means greater channel capacity and storage and lower flood crest heights.

The meander width of a stream is a rough approximation of the limits within which the river erodes out new channels over the years. It is possible to conclude that dikes for the river reach near Highway 69 should be placed at least 150 feet back from the centre line of the river channel.

At Val Caron, where a dike is recommended to protect the extensive development on the low-lying lands adjacent to the river, the dike may be placed closer to the river provided that the opposite side of the river is left undeveloped and open to take care of the overflow. In any case, the dike should not be placed closer than 60 feet to the edge of the present channel. Assuming that one or more of the storage areas recommended earlier in this report will be constructed, it is recommended that the Val Caron dike be constructed to elevation 937.5 feet at No. 69 Highway rising uniformly to elevation 939.5 at the Fifth Concession road. The estimated cost of this work is $72,000 plus the cost of the necessary land. This provides for an 8-foot top width and if

it is desirable to widen this to a 30-foot top width to accommodate a roadway the cost would be $85,000. The proposed location and alignment of this scheme is shown in Figure 5. If the reservoirs are not built the dike should be at least 2 feet higher.

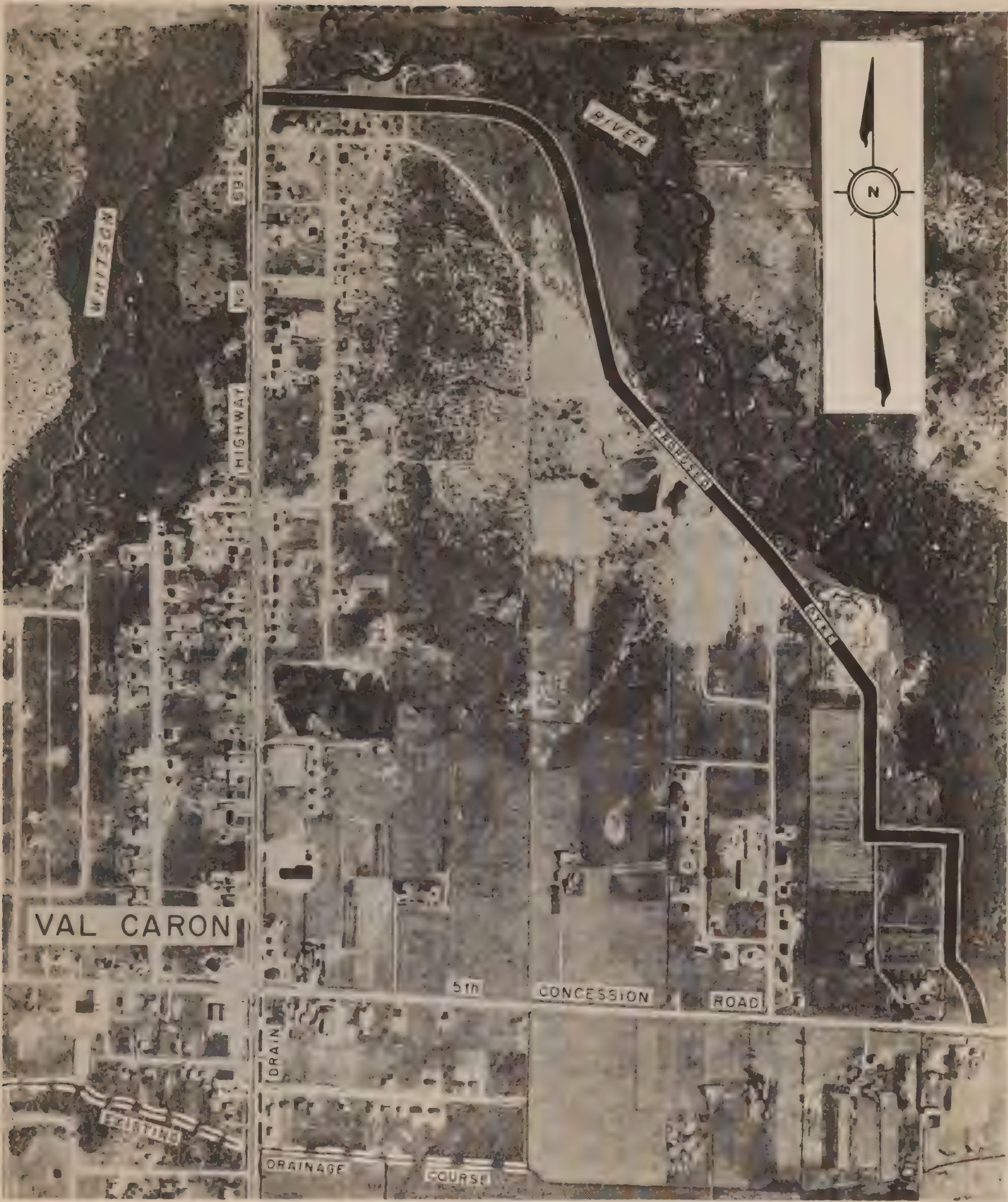
The fact that a dike exists is not a guarantee that the inhabitants of the diked area are going to be completely free of flood damage. A flood greater than the design flood might occur causing the river to overtop the dikes. Once the dikes are overtopped the flooding behind the dikes can be as troublesome and costly as if there had been no dike built. In order to provide adequate drainage within an area protected by the dike it is often necessary to install a pumping plant. In some cases the topography may be such that alternate gravity drainage can be provided.

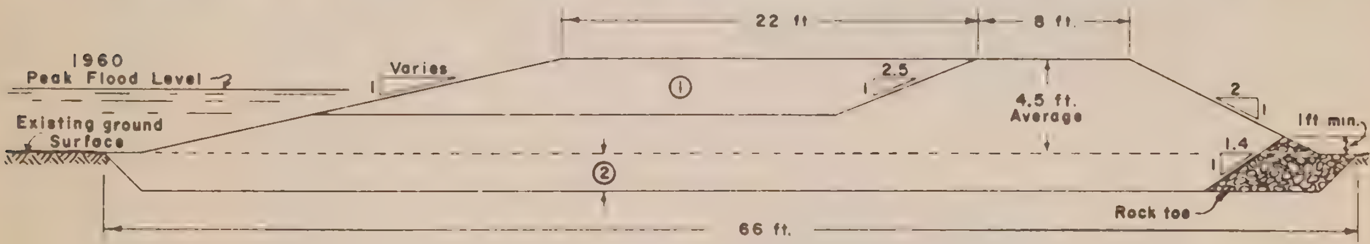
(3) Diversions

If reservoirs, channel improvements or dikes are impracticable or ineffective it is sometimes possible to detour the stream or part of it around the flood area, or in some cases divert it to another watershed. This method has been used successfully by other Conservation Authorities to solve their flood problems, the best known case being the Brampton Diversion on Etobicoke Creek. However, it does not appear to be a practical solution for any of the present flood problems on the Whitson River.

(4) Cut-Offs

Like a diversion on a small scale, a cut-off is a channel dug across a narrow neck of a meander in the river. It eliminates a bend or series of bends and materially shortens the channel length which increases the slope of the river locally and speeds up the water as illustrated in Figure 6. Since the Whitson River has a multitude of meanders giving channel lengths one-and-a-half to three times the straight line





① Provided suitable material can be obtained, this cross-sectional area of the dyke may not be required unless a roadway is to be constructed on top of the dyke.

② All organic top soil to be removed. This may vary from a few inches to three or more feet in sections.

FIG. 5

PLAN AND
TYPICAL CROSS-SECTION
of
PROPOSED VAL CARON DYKE

D.C.&D. CONSERVATION BRANCH 1961

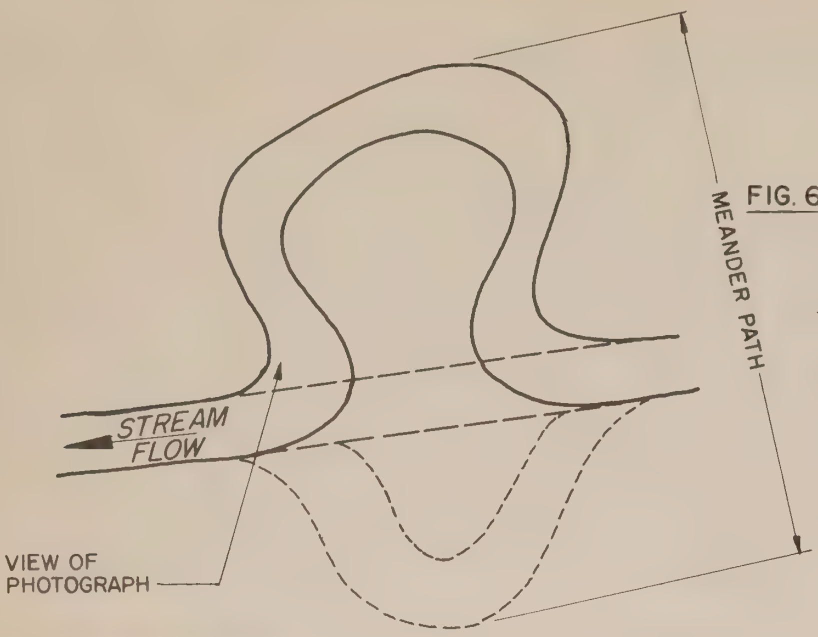
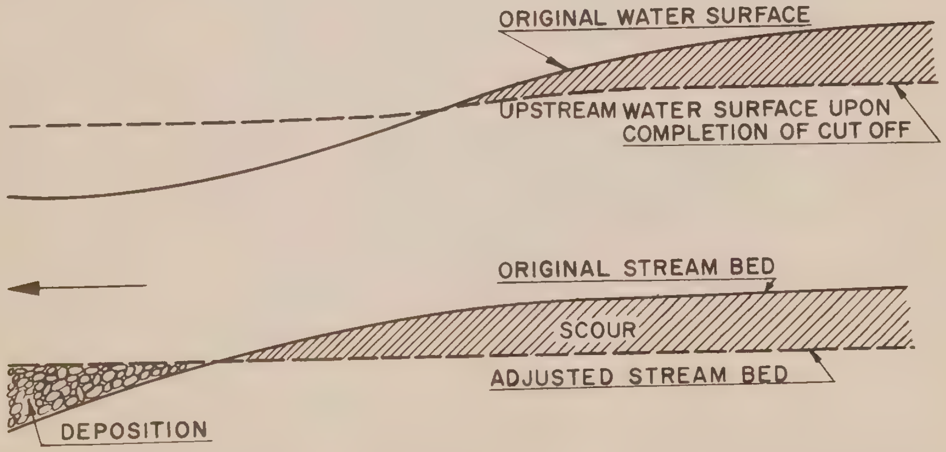


FIG. 6. SHOWING CHANGE IN STREAM PROFILE AND STREAM COURSE

THIS FORMER CHANNEL IS TYPICAL OF THE WHITSON RIVER COURSE. IT HAS BEEN BLOCKED BY DEPOSITS OF SAND IN A TIME OF HIGH WATER AND THE RIVER HAS DEVELOPED A NEW CHANNEL THROUGH THE FLOOD PLAIN.

THIS MEANDERING OF THE STREAM IS AN ADDITIONAL REASON FOR HAVING LARGE FLOOD PLAIN LIMITS.



STREAM PROFILE

CUT OFF'S CAN BE FORMED NATURALLY AS IN THE ABOVE PHOTO OR ARTIFICALLY BY EXCAVATION. THEY PROVIDE A MEANS OF LOWERING UPSTREAM W.L. AND INCREASING DOWNSTREAM W.L.

D. C. & D. CONSERVATION BR. 1961 C.S.V.

distance in many reaches, it would appear, at first sight, that the channel capacity could be substantially increased by making a series of cut-offs. Although cut-offs appear obvious and simple they are often rendered useless by the wily river. As the velocity increases, due to the increase in slope, the capacity of the water to carry soil from the river channel increases as described earlier. Rapid erosion takes place in the cut-off and the sediment load is deposited downstream from the cut-off which may nullify the work unless precautions are taken to stabilize the bed and sides of the new channel. Cut-offs could be constructed just downstream from Chelmsford to benefit Chelmsford, without any serious damage in the outlet area since the river winds through uninhabited scrub bush land downstream of Highway 544.

On the other hand, the scouring capacity of the river, if controlled, could be used to good advantage. If the series of rapids both above and below Chelmsford were removed, scouring could lower the bed and hence the flood crest height through Chelmsford and perhaps be beneficial as far upstream as Val Caron. However, in order to ensure that the bed level and flood crest level would not be increased at Chelmsford due to deposition of sediment from upstream, further study will be needed to find the bed load capacities of the channel and the variation in sediment transport at different discharge rates.

Both cut-offs and channel clearance are only temporary measures since the river will tend to meander and in time become as crooked as ever unless costly measures are taken to protect the improved channel.

(5) Land Drainage

This far the flood control problem has been described only for the main river channel. In many cases, especially on very flat terrain such as Rayside and Hanmer Townships, flooding is caused by the inability of excess water to drain to the main channel.

Tributary XI upstream of first road north of Highway 545, east of Hanmer, is choked with alder and willow.

Same tributary downstream of the above road has been cleared and has a much greater water carrying capacity.

This tributary watercourse in Blezard Township has been robbed of its discharge capacity by vegetation. Once opened, its capacity could be retained by a small amount of annual mowing and tending.

In every municipality drained by the Whitson River there are drainage courses which are drastically insufficient in capacity. In some cases roads have been built up and act as dikes causing ponding where the water would have previously been able to get away. In other cases, ditches have been allowed to grow up with alders and thick weeds until their capacity is seriously reduced. In still other cases drainage ditches have been thoughtlessly filled in. Some examples of these situations are shown in the photographs overleaf.

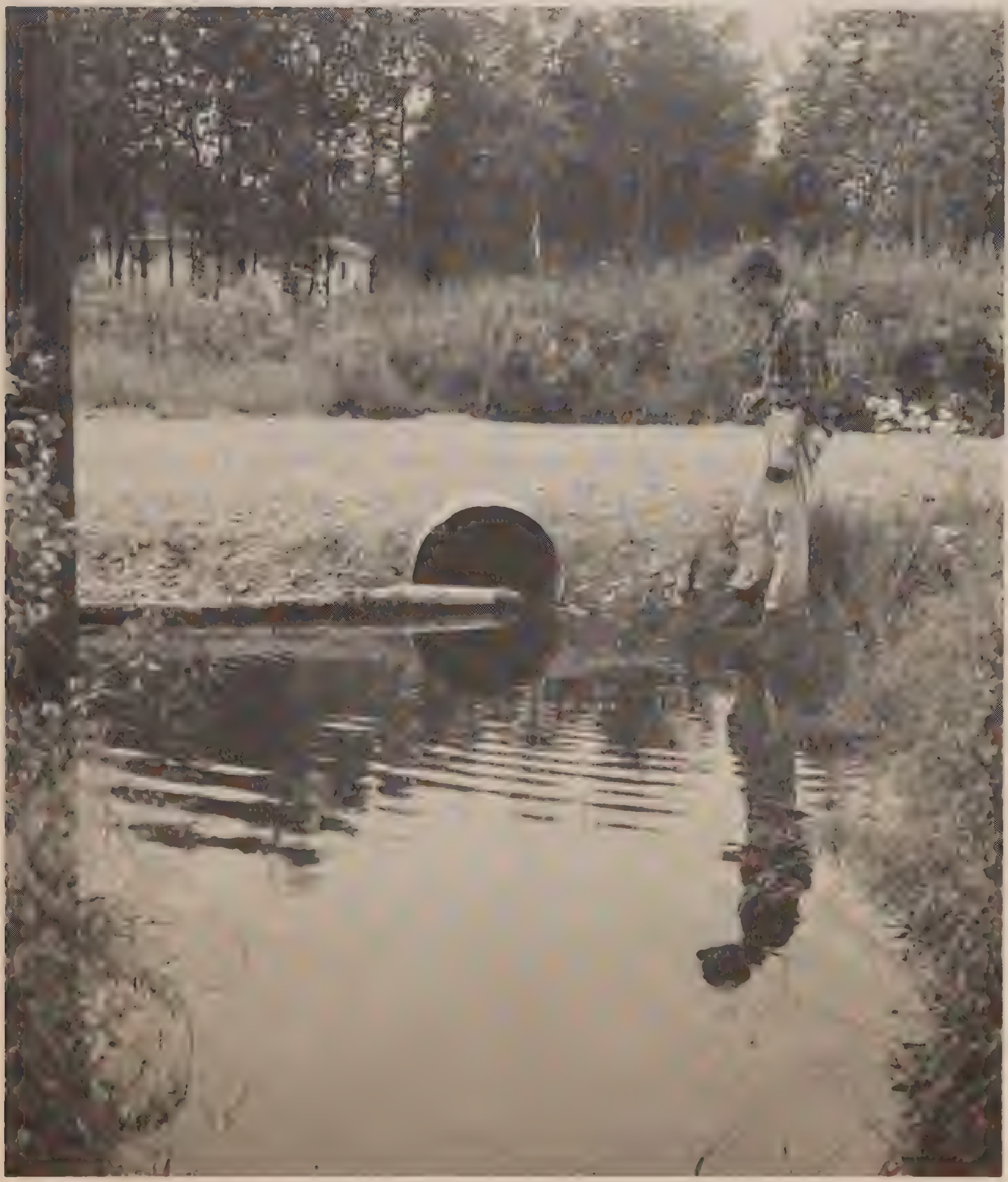
These examples are typical of the lack of consideration given to tributary drainage channels throughout the Whitson Watershed. Many other similarly unsatisfactory drainage situations could be cited.

In many cases, the tributary drainage channels had fair to good capacity when the land was being actively farmed. But in the past few years much of the land has been left uncultivated and weeds and alders have overtaken the ditches. The vegetation then trapped sediment from drainage water and gradually the ditches were silted in and robbed of their capacity. As subdivisions overtake the fallow land the tendency has been to ignore the condition of drainage courses left choked with weeds and sediment. Failure to recognize the drainage needs when subdivisions are laid out can lead to unhealthy and costly flood problems shortly after the new homes are inhabited - sometimes even before habitation. It is recommended that the Authority publicise the common sense approach of keeping the smaller tributary drainage channels open. Subdividers should be required to provide adequate drainage channels and to provide the municipalities or the Authority with an easement along the drainage course to allow for efficient and regular inspection and maintenance.

A good example of this condition is the ditch which drains a fair sized area on the east side of No. 69 Highway at Val Caron. Originally the ditch extended to the Whitson

River and helped drain the area on the south side of Val Caron astride No. 69 Highway. Soon after strip development, (heavy urban settlement along a highway) the adjacent property owners simply filled in the ditch with refuse and planted lawns and gardens. As a result the area east of the highway is now often flooded by surface run-off as there is no proper outlet to the main channel. This is just another example where a little forethought could have eased local flooding.

A 6' x 6' culvert under Highway 69 on tributary to Whitson, north of Val Caron.



A 2.5' diameter culvert, 100' downstream of the above highway culvert, has insufficient capacity resulting in ponding and flooding upstream.

CHAPTER 5

HUMAN CONTROLS

Previous sections of this report have outlined how some of the existing built-up areas might be protected from flood damages through physical control of the run-off water by dams, channel improvements, etc. While these controls are essential for the protection of existing urban areas they are not the most practical means of protecting those areas which may be urbanized in the future. All too often after some dams or dikes which give only a limited degree of protection have been built, people tend to think that floods have been eliminated. They proceed to build closer to the river than before. Then, when a flood occurs in excess of that for which protection has been provided, great damage and distress results. Even though billions of dollars have been spent in the past five decades on flood control structures in the United States the average annual losses due to floods have continued to increase largely because of haphazard developments. By adjusting the use of the land much of this suffering, damage and hazard brought on by flood events can be eliminated.

One method to be used in making this adjustment is "flood-plain zoning". Municipalities have the power to regulate the use of flood-plain lands under Section 30 of the Planning Act which states:

> "Section 30(a) - For prohibiting the erection of a building or structure for residential or commercial purposes on land which is subject to flooding or on land where, by reason of its rocky, low lying, marshy or unstable character, the cost of construction of said waterworks, sewage or drainage facilities is prohibitive."

All of the municipalities in the valley have been experiencing an increase in population in the last few decades but fortunately there is still much open land. It is at this stage while development is still relatively sparse that flood-plain zoning can be really effective. The municipalities

in the Whitson Valley have an advantage over the larger built-up communities of Southern Ontario in that there is still an opportunity to prevent residential and industrial development in the flood plain, rather than be forced to clean them up after floods. The time is now ripe for action by the Whitson Valley Conservation Authority to solicit the co-operation of all the member municipalities to pass by-laws designating flood-plain lands and restricting the use of these lands to recreation, forestry, agriculture and other low risk uses which will withstand flooding without any appreciable damage. By preventing the indiscriminate development and settlement of the natural flood plains, the problem of flooding to a large degree would be solved. Flood-plain zoning is analogous to municipal or planning area zoning which limits the use of certain lands for certain types of buildings or uses. Perhaps flood-plain zoning could be more accurately termed, sensible adjustment of land use to the flood peril. The steps involved in flood-plain zoning are: designation and classification of the land in terms of the risk; the establishment of standards of flood plain use; and finally, the most important step, rigid enforcement of the standards.

In order to provide a working basis for a zoning scheme some of the lands flooded in the spring of 1960 have been outlined on aerial mosaics, copies of which are attached in the following pages. This 1960 flood line should not be interpreted to enclose all land which is subject to flooding. It is a minimum flood zone within which houses should not be built. As was pointed out earlier in this report, however, the 1960 flood appears to have been of the magnitude which may be expected to occur about once in 10 years on the average. Higher flood levels have occurred at Chelmsford in the past and can be expected in the future. With the advent of more and better flow records a more accurate outline of the area which

would be zoned as flood-plain lands, may be made. To assist the Authority and the member municipalities further in this regard a copy of a typical by-law is shown below:

TOWNSHIP OF ETOBICOKE
BY-LAW NO. 11,757
A BY-LAW TO PROHIBIT THE ERECTION
OF BUILDINGS AND STRUCTURES FOR
RESIDENTIAL OR COMMERCIAL PURPOSES
IN PART OF THE TOWNSHIP OF ETOBICOKE

WHEREAS aerial photographs have been taken showing the high water line reached by the waters of the Humber River and its branches in October 1954 and, from which photographs, contour maps have been compiled showing such line as a dotted line thereon, copies of which maps are attached to and form part of this by-law;

AND WHEREAS such high water line varies considerably in its location and it is deemed desirable to more accurately define the line of reference to contour lines for the purposes of this by-law;

AND WHEREAS it is deemed expedient to prohibit the erection of buildings and structures for residential or commercial purposes in that part of the Township of Etobicoke lying within the bed of the Humber River and its branches, and lying between the red lines marked on the said maps and the normal bed of the Humber River and its branches, by reason of the fact that such land is subject to flooding.
NOW, THEREFORE, THE MUNICIPAL COUNCIL OF THE CORPORATION OF THE TOWNSHIP OF ETOBICOKE ENACTS as follows:-

1. No person shall erect any building or structure for residential or commercial purposes in that part of the Township of Etobicoke lying in the bed of the Humber River and any of its branches, and between the red lines as designated on the maps attached hereto, and the normal bed of the Humber River and its branches, provided, however, that this by-law shall not operate to prohibit the erection of buildings and structures designated to be used in connection with the use of the said lands for parks or recreational purposes.

2. This By-law shall not apply to any building or structure which, on the day of passing of the By-law, is erected on the said lands, nor shall the By-law apply to any building or structure the plans for which have, prior to the day of the passing of the by-law, been approved by the Building Commissioner so long as the building or structure, when erected, is used for the purpose for which it was erected.

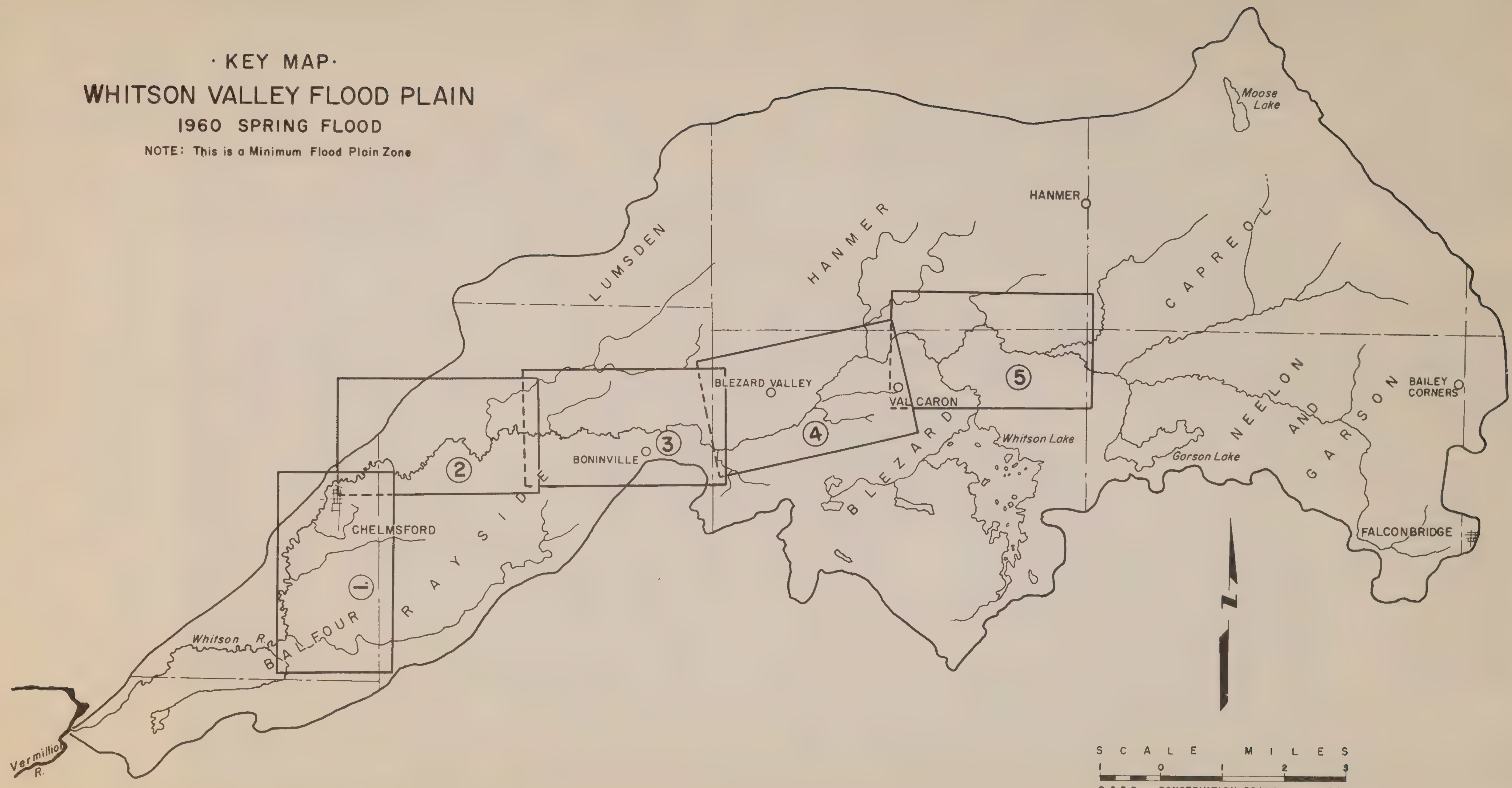
3. Any person convicted of a breach of any of the provisions of this By-law shall forfeit and pay, in the discretion of the Convicting Magistrate, a penalty not exceeding the sum of Three Hundred Dollars ($300.00) exclusive of costs, for each offence, and every such penalty shall be recoverable under The Summary Conviction Act.

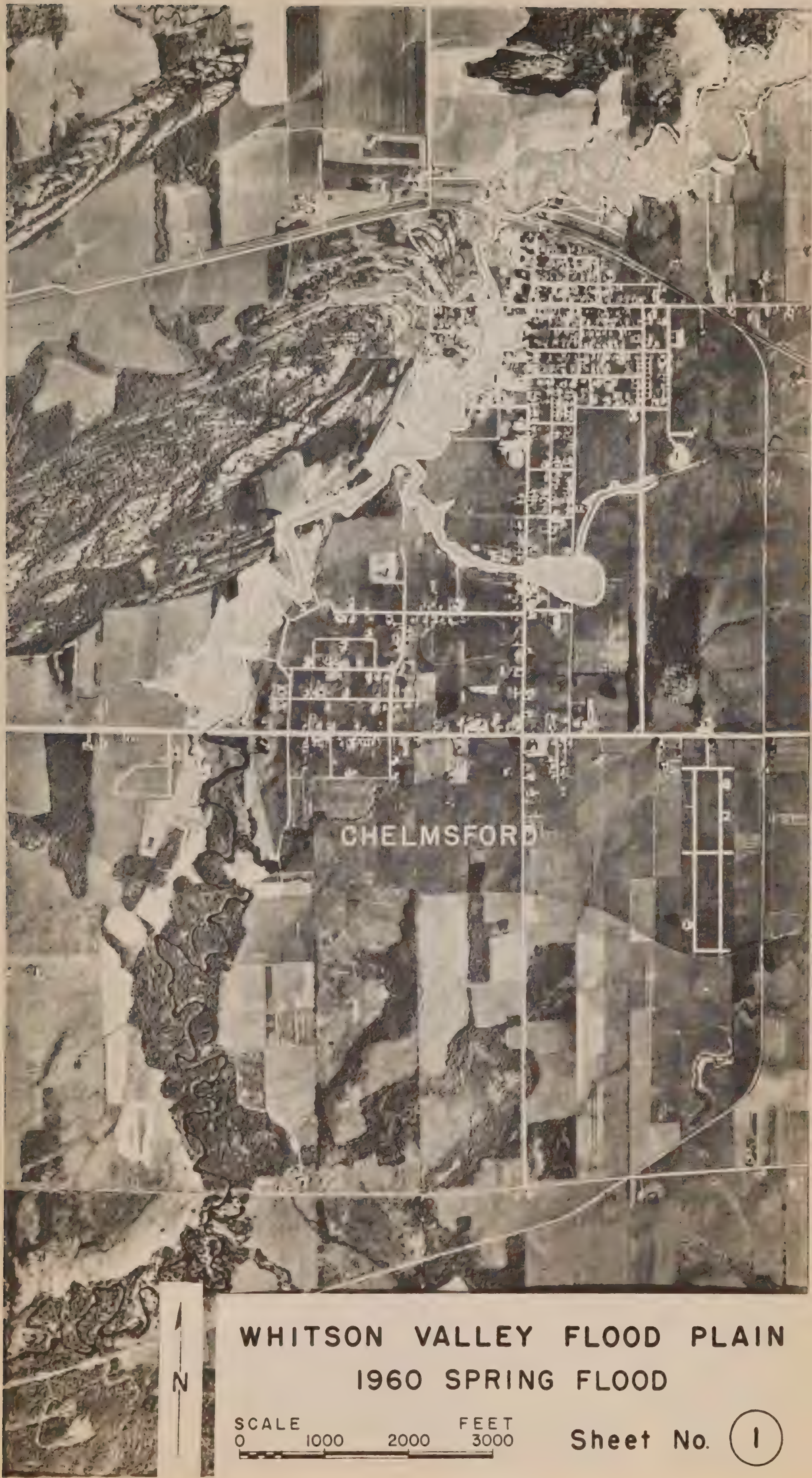
4. The provisions of Clause 3 shall be in addition to any other remedy which the Corporation of the Township of Etobicoke or a ratepayer thereof may have to restrain by action a contravention of this By-law.

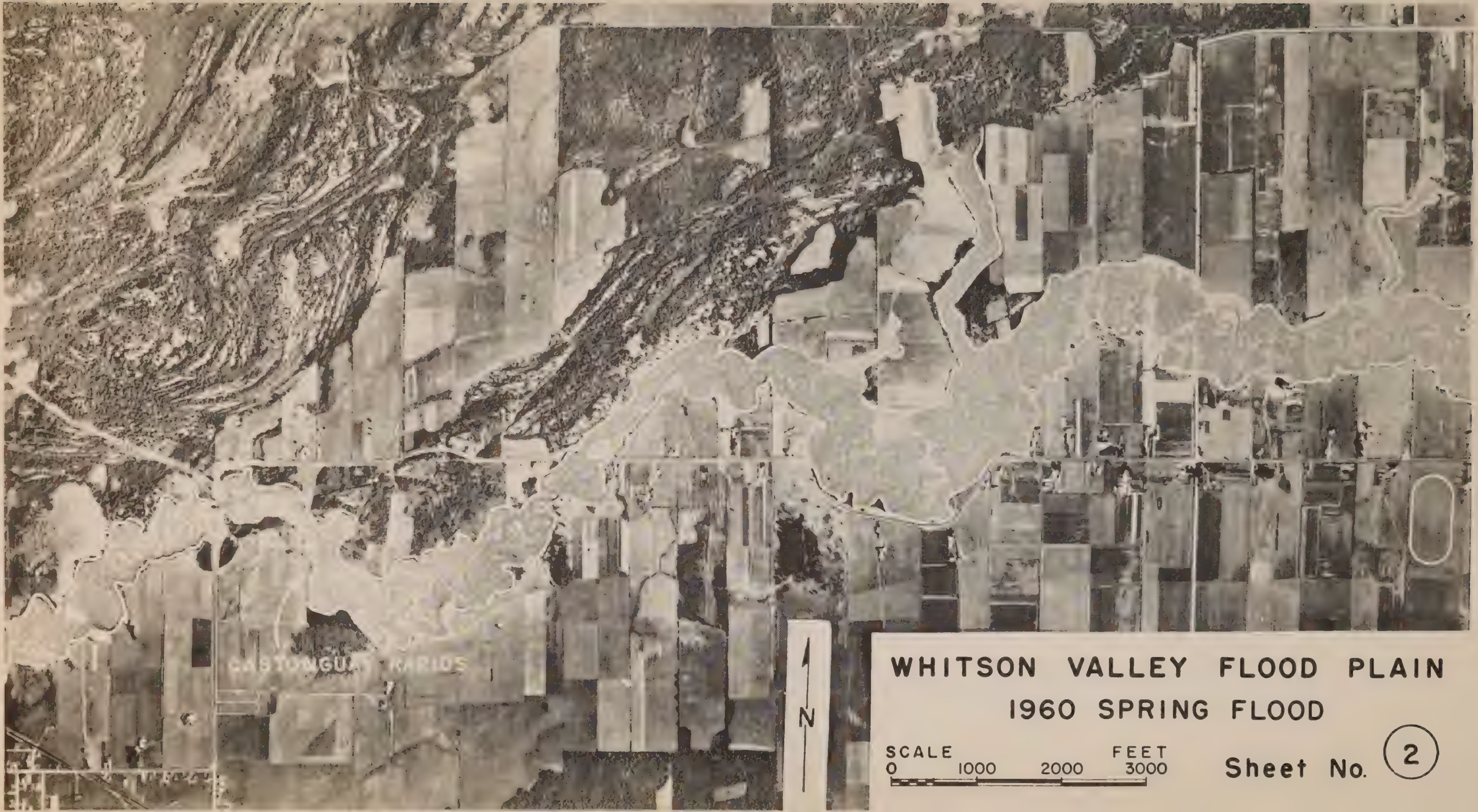
5. Subject to the approval of The Ontario Municipal Board, this By-law shall come into force and take effect upon the date hereof.

READ a first, second and third time and passed in Council this 5th day of November, A.D. 1956.

W.B. LEWIS
Reeve
S.W. ECKERSLEY
Clerk


· KEY MAP ·
WHITSON VALLEY FLOOD PLAIN
1960 SPRING FLOOD
NOTE: This is a Minimum Flood Plain Zone
LUMSDEN
HANMER
HANMER
CAPREOL
Moose Lake
NEELON AND GARSON
BAILEY CORNERS
FALCONBRIDGE
Garson Lake
Whitson Lake
BLEZARD
BLEZARD VALLEY
VAL CARON
BONINVILLE
RAYSIDE
BALFOUR
CHELMSFORD
Whitson R.
Vermillion R.
1
2
3
4
5
N
SCALE MILES
1 0 1 2 3
D.C.&D. CONSERVATION BRANCH 1961


CHELMSFORD
N
WHITSON VALLEY FLOOD PLAIN
1960 SPRING FLOOD
SCALE FEET
0 1000 2000 3000
Sheet No. 1


WHITSON VALLEY FLOOD PLAIN
1960 SPRING FLOOD
SCALE
0 1000 2000 3000
FEET
Sheet No. 2
N


BENINVILLE
N
WHITSON VALLEY FLOOD PLAIN
1960 SPRING FLOOD
SCALE
0 1000 2000 3000
FEET
Sheet No. 3


WHITSON VALLEY FLOOD PLAIN
1960 SPRING FLOOD
SCALE
0 1000 2000 3000
FEET
Sheet No. 4
N


VAL CARON
N
WHITSON VALLEY FLOOD PLAIN
1960 SPRING FLOOD
SCALE FEET
0 1000 2000 3000
Sheet No. 5

CHAPTER 6

COMMUNITY PONDS

1. General

The benefits being derised from community ponds are becoming increasingly appreciated throughout the Province, especially in the heavily populated areas. This can be seen by the large numbers of people who each summer flock to the various bodies of water throughout the Province, however small they might be. Flooded gravel pits, quarries, old mill ponds, newly constructed ponds and even plain stretches of river are attracting an increasing number of people each year. This has caused serious overcrowding in some areas and the Conservation Authorities are strongly advised to prepare a program for the development of community ponds to meet this demand.

The advantages of such ponds are numerous. Besides providing a place for recreation, their proximity to a community enables the water to be used for fire-fighting purposes. Recently the water from such a pond was used to douse a large fire which might otherwise have destroyed a whole community, and there have been other instances where local buildings have been saved in the same manner.

Another advantage of a community pond is its water conservation features. All too often, especially in newly developed areas, an excessive amount of annual precipitation is allowed to flow down the streams and be wasted. Any structure therefore, which tends to conserve a portion of the precipitation, aids in maintaining the ground water table level which ensures more water for the drier summer months.

A further advantage of a community pond is its ability to provide habitat for various forms of wildlife. It can be stocked with fish and, where conditions are favourable, wildfowl and other forms of wildlife can be encouraged. Besides these material benefits the pond, if properly managed, can have

Downstream of Main St. Bridge Chelmsford, Spring 1960. This is the area which would be flooded by a small recreation dam located below Chelmsford.

- Same view Aug. 1960

Whitson River and wooded flood plain, one-half mile east of Chelmsford suitable for recreation development.

an aesthetic value which will enhance the general appearance and well-being of any community.

2. Suggested Sites

Unlike most of the watershed areas in Southern Ontario there are no existing mill-ponds or suitable abandoned gravel pits which could be developed for this purpose on the Whitson Watershed. There are, however, many deep ox-bows and sections of the main Whitson River which could be developed for recreation purposes without aggravating the flood problem. Early consideration might be given to the construction of a small removable type dam about one half mile downstream from the Main Street bridge in Chelmsford. With this type of dam the sections are put in place in the early summer time to maintain a basin for swimming, boating and fishing as well as providing additional water for fire protection and municipal supply. The sections are removed in the fall in order not to impede the high spring flows and cause higher water levels which would aggravate the flooding. Similarly sections would be removed during any sudden summer storm that threatened to cause flooding. This dam would be similar to the Boyd Conservation Area dam of the Metropolitan Toronto and Region Conservation Authority shown in the accompanying photographs.

Upstream from Chelmsford near the Rayside-Balfour township line there is a very picturesque reach of flood plain which might readily be developed for public use. To the north of the river the rugged rock shoulder could serve as a scenic outlook. Further upstream in Blezard Township just south of the hamlet of Blezard Valley another reach of the flood plain, which is very pleasant in the summertime, might be developed as public open space. Again, upstream of Val Caron parts of the flood-plain could be used as an instructive conservation area in conjunction with channel improvements and diking work.

Receding flood waters on east side of Highway 69 at Val Caron. Highway 69 acted as a dam resulting in serious flooding on the east side of the Highway.

Rapids below Chelmsford as indicated on the base-map. A low removable dam such as the one shown below could maintain a recreation and water supply pool through most of the town of Chelmsford.

Metropolitan Toronto and Region Conservation Authority Recreation Dam, Boyd Conservation Area. The steel posts are removed in the fall in order to prevent ice jams with their accompanying upstream flooding, and to allow the high spring flows to pass unimpeded.

CHAPTER 7

FIELD SURVEYS AND SUMMARY

1. Surveys

Surveys made during this study were purely of a preliminary nature but were considered sufficient to outline the water problems of the area and indicate to some extent what the Authority could do to alleviate the problems attendant upon the Whitson River and its tributaries.

As indicated throughout the report, accurate basic data of stream flows and precipitation which are essential for a study of this type were non-existent. As a result a great deal of time was spent consulting local officials and residents to obtain as much information on the past flow conditions and the associated problems as possible. Rainfall and stream flow gauges were established and although the records obtained were of little assistance at this time these will be invaluable for the future studies of the area. The stream flow gauges are being continued but the rainfall gauges had to be abandoned through the lack of interested observers.

There was no large scale detail mapping of the area available which necessitated considerable field survey work to establish river sections, gradients and contour intervals. Levels were run between Geodetic Survey of Canada bench marks and 36 intermediate bench marks were established throughout the watershed. (This bench mark data is available from the Conservation Authorities Branch, Department of Lands and Forests). The river valley was cross-sectioned at suitable intervals from the Vermillion River up as far as the proposed Bailey Reservoir site. These cross sections, together with the slope measurements obtained by the levels and the high water marks obtained from local residents enable estimates of flow to be made for past floods. Also the sections were used to delineate the extent of the flood plain for flows of these magnitudes. More detailed

topographical surveys were made of the Val Caron flooded area and for each of the remedial measures proposed in this report.

The contours for the Bailey Reservoir were determined by stereo-projection from aerial photographs and the storage value computed for this site is believed to be within 10 per cent. Storage capacities of the Whitson and Garson Lake projects were determined on a straight depth basis only, using the existing surface areas of these lakes, and do not take into account the increase in area as the lake levels are raised. Therefore, these storage values would be on the conservative side. Cost estimates are also of a preliminary nature but well within the limit of accuracy required at this stage for the Authority to assess the relative benefits and their ability to finance the works required to relieve the flooding.

2. Summary

In the foregoing report the general physical characteristics of the area under study have been described and/or indicated on maps. These include the size and shape of the area, types of soil and their origin, topographical features, length and gradients of the river and its tributaries and the municipalities within the area.

A brief outline of the more recent floods, and their extent, has been given. These accounts cover the period since 1927 and indicate that at least four severe floods have occurred in this interval. These floods have caused considerable damage and inconvenience and, as pointed out, even greater floods can occur in the future and should be provided for when considering control measures. Floods in this area, as in most areas in Ontario, usually occur during the spring break-up. Many result from ice jams but all may be attributed to encroachment of the flood plain.

Reservoirs, which would serve the multiple purpose uses of flood control and summer flow have been located

and, if properly regulated, would control most of the flooding particularly the nuisance type floods which occur almost annually. These sites have been described and an estimate of cost is given for each. Expedient measures of channel improvements have also been listed and a dike system recommended for the Val Caron area. Such methods are not true conservation measures and are only recommended where control by means of reservoir storage, which permits a wider use to be made of the water available in the area, are not practical.

The physical controls, reservoirs, dikes, channel improvements, described will protect parts of the watershed from a 1960 type flood; they will also reduce the levels which might be reached by a once in a 100-year flood but they will not eliminate flooding. Flooding will always occur and will have to be endured if the inhabitants persist on encroaching on the flood plain. Val Caron is certainly not the only place subject to flooding in the valley, it has merely received the greater publicity. Val Caron is the forewarning of what might be expected if strip development is allowed to continue on the flood plain along the Whitson River in all the municipalities from its source to its confluence with the Vermillion River.

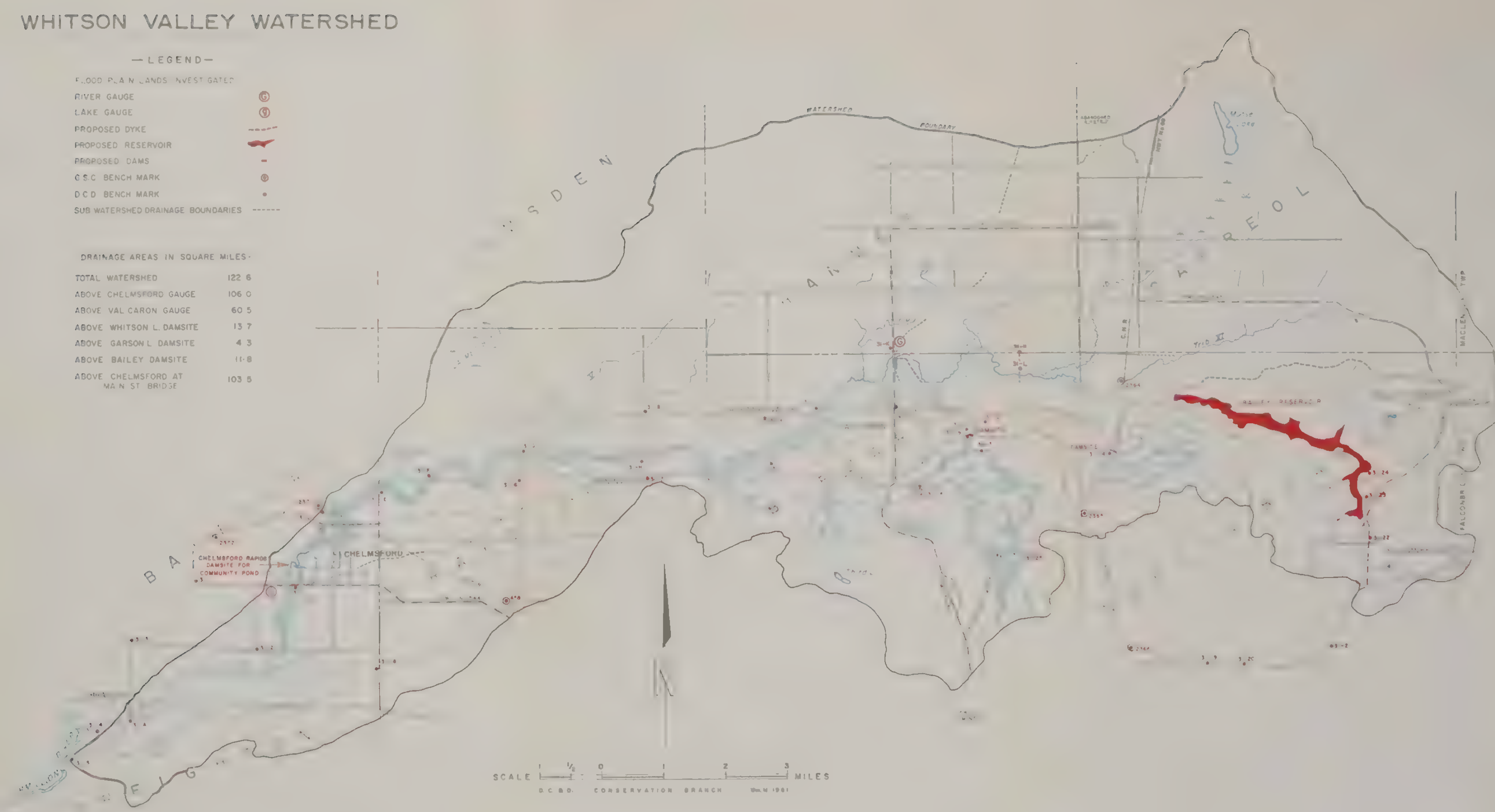
The zoning or flood plain management means of flood control has been stressed. This provides for the restricted use of the low-lying flats adjacent to the river to those compatible with the flood hazard. The wise management of such areas serves the double purpose of reducing the amount of flood damage, inconvenience and possible loss of life and, at the same time, provides for the free passage of the high flows which might otherwise be obstructed by buildings.

Some of the flood-plain lands have been indicated on mosaics made from aerial photographs to assist the Authority in outlining the flood vulnerable areas. A typical by-law for the proper zoning to prevent the unwise development of such areas is also included for its assistance.

From a study of physical controls and their costs it appears that the most economical long-term flood control method is the regulated use and wise management of those areas adjacent to the river and its tributaries which are subject to periodical inundation.

In addition to large storage projects community ponds serve a valuable function in the water conservation program and this has been briefly outlined in the foregoing report. Several areas which could be developed for recreation with water facilities have been indicated one of which with a small removable type dam could create a sizeable pond. This type is quite commonly used in other Conservation Authorities and has proved to be quite satisfactory.

Finally, a brief description of the field survey has been given to indicate to the Authority the scope of the study and the reliance that may be placed upon the data presented.



WHITSON VALLEY WATERSHED
— LEGEND —
FLOOD PLAIN LANDS INVESTIGATED
RIVER GAUGE
LAKE GAUGE
PROPOSED DYKE
PROPOSED RESERVOIR
PROPOSED DAMS
G.S.C. BENCH MARK
D.C.D. BENCH MARK
SUB WATERSHED DRAINAGE BOUNDARIES
DRAINAGE AREAS IN SQUARE MILES
TOTAL WATERSHED 122 6
ABOVE CHELMSFORD GAUGE 106 0
ABOVE VAL CARON GAUGE 60 5
ABOVE WHITSON L. DAMSITE 13 7
ABOVE GARSON L. DAMSITE 4 3
ABOVE BAILEY DAMSITE 11·8
ABOVE CHELMSFORD AT MAIN ST. BRIDGE 103 5
WATERSHED BOUNDARY
CHELMSFORD RAPIDS DAMSITE FOR COMMUNITY POND
CHELMSFORD
BAILEY RESERVOIR
SCALE 1/2 0 1 2 3 MILES
D.C.&D. CONSERVATION BRANCH

ABBREVIATIONS, EQUIVALENTS AND DEFINITIONS

Abbreviations

ac. ft.	is the abbreviation for acre foot which is the equivalent to 43,560 cubic feet and is the quantity of water required to cover one acre to a depth of one foot.
B.O.D.	is the abbreviation for Biochemical Oxygen Demand and is a measure of the oxygen that will be demanded by the material in the course of its complete oxidation biochemically. It is determined by the availability of the material as a bacterial food and by the amount of oxygen used by the bacteria during its oxidation.
c.s.m.	is the abbreviation for cubic feet per second per square mile and is the average number of cubic feet of water flowing per second from each square mile of drainage area.
c.f.s.	is the abbreviation for cubic feet per second and is the unit generally used to express discharge or the rate of flow.
G.S.C.	is the abbreviation for Geodetic Survey of Canada which refers to the official datum of elevations above mean sea level as established by the Geodetic Survey of Canada.
M.P.N. or m.p.n.	most probable number
ML or ml.	millilitre
P.P.B. or p.p.b.	parts per billion
P.P.M. or p.p.m.	parts per million
PH or ph	value measure of acidity or alkalinity

Equivalents

1 c.f.s.	= 6.25 imperial gallons per second
1 c.f.s. for 1 day	= 1.98347 acre feet or approximately 2 acre feet
1 c.f.s. for 1 year	= 724 acre feet
1 ac. ft.	= 271,472 Imperial gallons

1,000,000 Imperial gallons per day = 1.86 c.f.s.= 3.6836 ac.ft.

Definitions

AQUIFER is a water-bearing structure or formation

BASE FLOW is that portion of the stream flow which originates from the ground water storage.

BOOST STORAGE is the storage required to increase the head of water over the discharge tubes in order that they may be able to discharge the required flow.

CAREX - sedges - grass-like plants common to wetlands.

CHANNEL CAPACITY or "IN BANK" FLOW is the maximum flow which is contained within the river banks and does not overflow the adjacent low lands.

CHANNEL CAPACITY STORAGE is the volume of water that must be impounded in order that the stream flow will not exceed the channel capacity flow or stage.

DAM is a structure in and across a river valley to impound, control and otherwise regulate the river flow.

DEAD STORAGE is the amount of water kept in a reservoir at all times for the purpose of protecting the artificial and natural water seals at the base of the dam.

DISCHARGE TUBE OR CONDUIT is an opening through the base of the spillway to provide means for discharging water when the water level of the reservoir is below the spillway level.

DRUMLINS are oval shaped hills laid down by glaciers. They usually all point in the same direction.

FLOOD is an overflow or inundation coming from a river or other body of water.

FLOOD CONTROL is the prevention of flooding by controlling the high water stages by means of storage reservoirs, dikes, diversions or channel improvements such as widening, deepening and straightening.

FLOOD CONTROL STORAGE is the total volume of water that must be impounded during a given flood in order that the stream flow will not exceed the channel capacity flow or stage and is equal to the sum of the channel capacity, dead, boost and operational storages.

FLOOD CREST is the maximum height or stage that the flood waters reach during any one flood period.

FLOOD HYDROGRAPH is a hydrograph which covers only the flood period or time interval during which the river flow is above the flood stage.

FLOOD RATIO is the ratio of peak flow to the average flow for the flood period.

FLOOD STAGE is an arbitrary flow stage which varies from place to place and from season to season and is that flow or water level at which the water threatens to do damage.

FREEBOARD is the vertical distance between the maximum permissible water level and the top of the dam or dikes.

GROUND WATER is the portion of the subterranean water which occurs in the zone of saturation.

GROUND WATER STORAGE or RESERVOIR is a term used interchangeably with aquifer.

HORIZONS are the layers of soil i.e., topsoil, subsoil, etc.

HYDRAULICS as applied to conservation deals with the measurement and control of run-off from river drainage basins.

HYDROGRAPH is a plot of flow against time and is a correct expression of the detailed run-off of a stream resulting from all the varying physical conditions which have occurred on the drainage area above the gauging station previous to the time which it represents.

HYDROLOGY is the science which deals with the occurrence and distribution of water in its various forms over and within the earth's surface. As applied to conservation it deals more specifically with that portion of the hydrologic cycle from precipitation to re-evaporation or return of the water to the seas and embodies the meteorological phenomena which influence the behaviour of the waters during this phase of the cycle.

MORAINE is a ridge of sand or clay material deposited at the edge of, or between, lobes of a glacier.

OPERATIONAL STORAGE is additional storage that is required to provide a safety factor to enable the controller to regulate the discharge from a dam so as not to exceed the channel capacity flow or stage.

PHYSIOGRAPHY is the description of the surface features of a landscape.

RATE OF RUN-OFF is the rate at which water drains from an area. Usually expressed in cubic feet per second (c.f.s.).

RATE OF RUN-OFF PER SQUARE MILE is the average number of cubic feet per second of water flowing from each square mile of area drained (c.f.s./sq.mi. or c.s.m.).

RESERVOIR is the body of water created by the construction of a dam.

RESERVOIR CAPACITY is the maximum amount of water that may be contained within the reservoir without exceeding the maximum permissible water level. Usually expressed in acre feet.

RUN-OFF is the amount of water which reaches the open stream channels and may be broadly defined as the excess of precipitation over evaporation, transpiration and deep-seepage.

RUN-OFF DEPTH IN INCHES is the depth to which the area would be covered if all the water flowing from it were conserved and uniformly distributed over the surface.

SPILLWAY is that part of a dam over or through which the water is discharged.

SPILLWAY CAPACITY is the maximum amount of water that may be discharged over the spillway without exceeding the maximum permissible water level in the reservoir.

STREAM GAUGE is a measuring device used to determine the elevation of the water surface at selected points - usually a graduated rod fixed in an upright position and set to a known elevation from which the gauge readings are obtained by direct observation. An automatic type gauge is a mechanically operated recording instrument which gives a continuous record of water surface elevations.

SUMMER FLOW STORAGE is that volume of water remaining in a reservoir which may be used to augment the low flows and is equivalent to the maximum storage capacity of the reservoir less the dead storage, evaporation and ice losses and the space reserved for flash floods.

TILL is an heterogeneous mixture of clay, sand and stone material deposited by glaciers.

WATER or CLIMATIC YEAR is a 12-month period from October 1 to September 30. The water year was found to be a more convenient form than the calendar year for the purpose of stream flow studies as it groups together those months in which the water losses due to evaporation and vegetation demands are at a minimum (October - March) and those during which the losses are high (April - September).

WATER TABLE is the upper surface of the zone of saturation.

ZONE OF SATURATION is the portion of the earth which is saturated with water.